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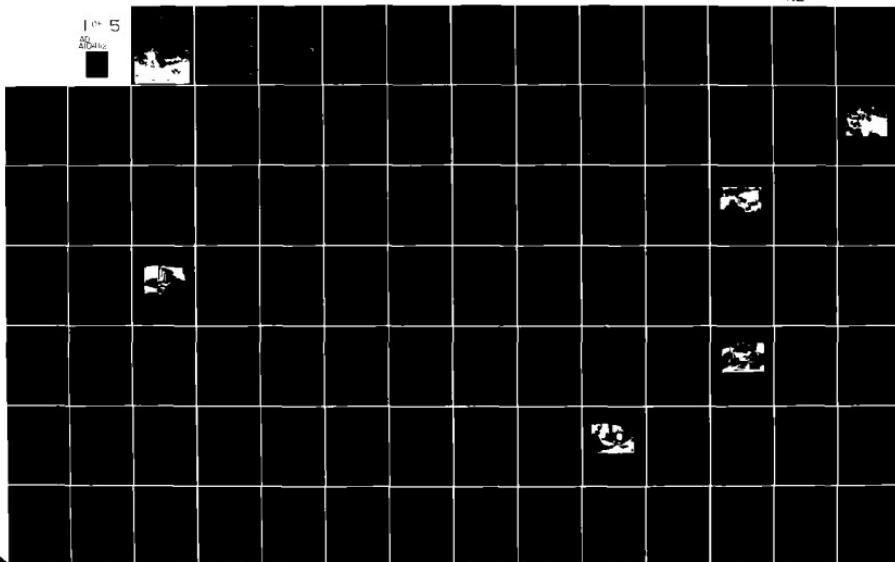
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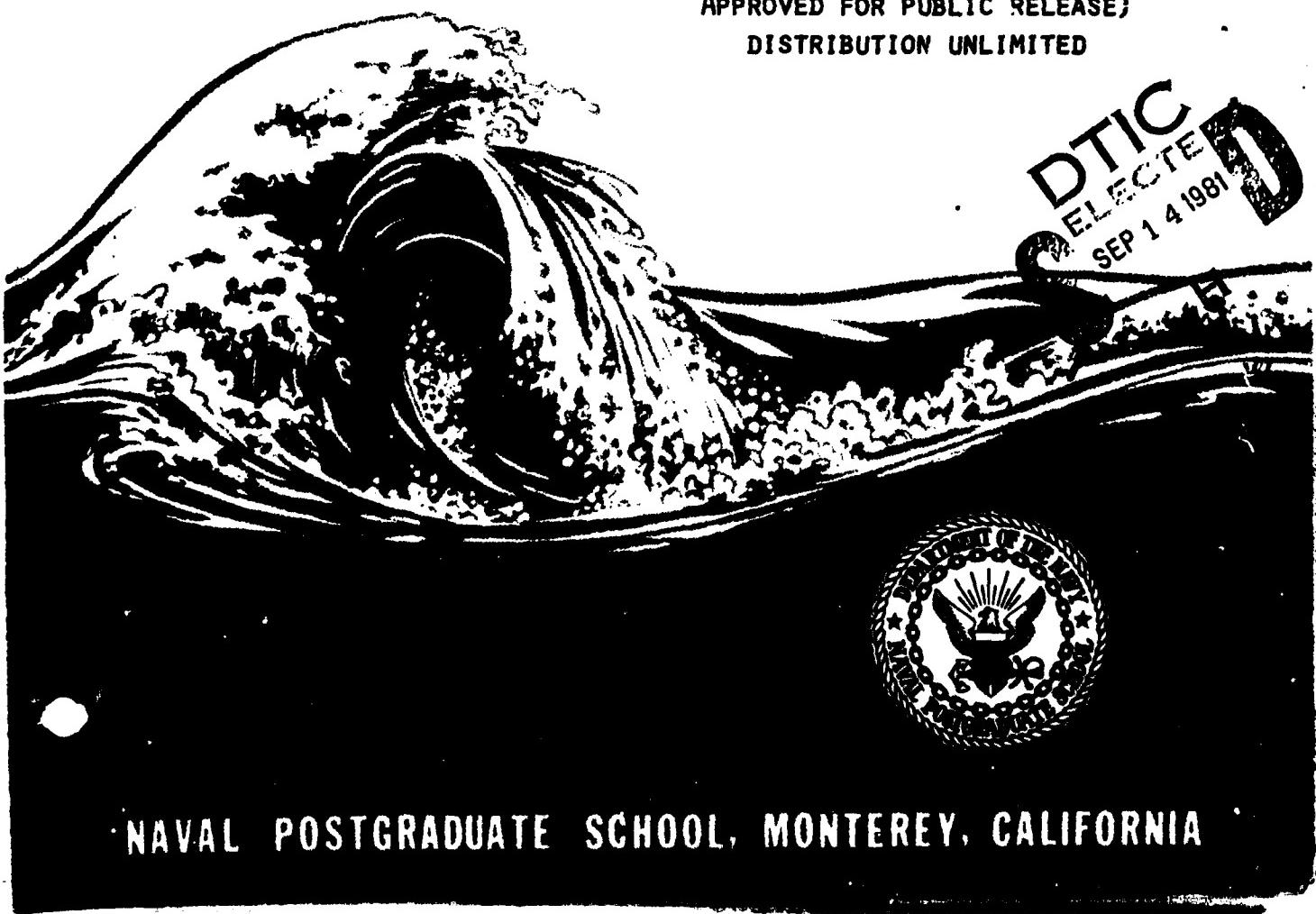
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A SUMMARY OF THE  
NAVAL POSTGRADUATE SCHOOL  
RESEARCH PROGRAM

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REPORT FOR THE PERIOD  
1 OCT 1979 TO 30 SEPT 1980

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NAVAL POSTGRADUATE SCHOOL  
Monterey, California

Rear Admiral John J. Ekelund  
Superintendent

David A. Schrady  
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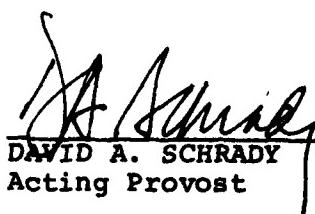
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  <b>This report contains 230 summaries on research projects which were carried out under funding to the Naval Postgraduate School Research Program. This research was carried out in the areas of Computer Science, Mathematics, Administrative Sciences, Defense Resources Management, Operations Research, National Security Affairs, Physics and Chemistry, Electrical Engineering, Meteorology, Aero-nautics, Oceanography and Mechanical Engineering. The Table of Contents identifies the areas of research.</b>		

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## A SUMMARY OF RESEARCH ACTIVITIES

### INTRODUCTION AND BACKGROUND

Research activities performed at the Naval Postgraduate School (NPS) during fiscal year 1980 are abstracted in this summary volume. These results are due to the efforts of principal investigators (faculty members at NPS) with, in most cases, student contributions through activity leading to a thesis in pursuit of an advanced degree.

The importance of research at NPS is recognized in the mission statement:

"...to encourage a program of research in order to sustain academic excellence."

Research performed at an educational institution such as NPS provides not only the benefits of original investigations inherent in all research activities but, in addition, contributes to the knowledge base and vitality of the educational activities at the institution. Sponsor benefits include augmentation of research efforts with student activity, and exposure of students to areas of current concern.

The Naval Postgraduate School provides a unique interface between academic institutions and the Navy. As such, the research projects undertaken are, in general, clearly related to Navy and DOD interests. A substantially larger fraction of the R&D effort at NPS is in the exploratory development category than would be found in most universities. This is a result of student interests as well as faculty interest created by the environment at NPS.

Support of NPS research activities has diversified to presently include more than seventy separate sponsoring agencies. The enclosed summaries indicate the level of activity and the diversity of efforts in support of both education and R&D.

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TABLE OF CONTENTS

	<u>PAGE</u>
<b><u>DEPARTMENT OF COMPUTER SCIENCE</u></b>	
Chairman, Department of Computer Science	1
L. A. Cox, Jr.	Exploration of Performance Prediction Techniques for Advanced Computer Architectures
L. A. Cox, Jr.	A Microprocessor Based Secure Archival Storage System
U. R. Kodres M. L. Cotton R. Panholzer	Emulation of a Multi-Microcomputer Architecture for the SPY-1A Control Computer
U. R. Kodres R. R. Schell	Operating System Structures for Distributed Multi-Microcomputer Systems
B. J. MacLennan	Advanced Methods for Software Development
G. A. Rahe C. E. Irvine	Application of Auto-Instruction to Undersea Surveillance
R. R. Schell	Computer Security Vulnerability Evaluation
D. R. Smith	Towards a Unified View of Search Techniques
<b><u>DEPARTMENT OF MATHEMATICS</u></b>	
Chairman, Department of Mathematics	19
R. Franke G. Nielson	Interpolation of Scattered Data
R. Franke	Investigation of Foutz Test for Goodness-of-Fit
T. Jayachandran	Gaussian Stationary Markov Processes-Prediction Problems

	<u>PAGE</u>	
T. Jayachandran	JOAP Analysis-Determination of Sampling Intervals	25
I. B. Russak	A Conjugate Gram Schmidt Algorithm in Constrained Minimization Problems	27
A. L. Schoenstadt	Technical Assistance in Asbestos Abatement Estimation	29
P. C. C. Wang	Automation Technology and Technological Threat Forecasting Methodologies	30
 <u>DEPARTMENT OF ADMINISTRATIVE SCIENCES</u>		
Chairman, Department of Administrative Sciences		32
D. C. Boger	Industry Structure and Strategy: The Aerospace Industry	35
D. C. Boger	A Statistical Examination of Profitability in the Aerospace Industry	36
J. W. Creighton	Studies in Workloading, Maintenance Cost Allocation, and Maintenance Effort Planning	37
J. W. Creighton J. A. Jolly	Symposium Proceedings and Technology Utilization Enhancement	38
J. W. Creighton J. A. Jolly	Usage and Effectiveness of the Navy Civil Engineering Laboratory R&D Effort	40
R. S. Elster	Evaluation of the R&D CREDO at RTC Great Lakes	41
R. S. Elster	Relationships Between Educational Credentials and Military Performance Criteria -- An Evaluation of the General Educational Development (GED) Certificate	42
C. K. Eoyang R. T. Harris	Human Resource Management System: Research and Support Project	43

K. J. Euske	An Analysis of the Factors Affecting the Efficiency and Effectiveness of Management Control Systems	45
R. Evered	Development of Public Policy Case Materials	46
R. Evered	Futures Planning in Organizations	47
J. M. Fremgen S. S. Liao	The Allocation of Corporate Indirect Costs	48
D. V. Lamm R. Schill	Strategic Acquisition/Resources Market Planning	49
S. S. Liao	Measuring the Efficiency and Effectiveness of Governmental Activities	50
M. R. Louis	The First Years Out Study -- Career Transitions: Facilitating Recruit Adaptation	51
N. R. Lyons	An Empirical Study of Information Gathering Behavior	53
N. F. Schneidewind	Computer System Performance Evaluation	55
N. F. Schneidewind	Database Management and Distributed Systems	57
N. F. Schneidewind	Software Engineering (Software Maintainability)	58
R. Weissinger-Baylon	The Functions of Visual Mental Imagery	59
R. A. Weitzman	Sequential Testing for Selection	61
R. A. Weitzman	Stepwise Pattern Analysis with Incomplete-tree and Bayesian Estimation	63
D. Whipple R. Harris G. Thomas K. Kocher	Navy Health Care Systems: Professional/Paraprofessional Personnel Mix Study (HEALPERS)	64

	<u>PAGE</u>	
<u>DEFENSE RESOURCES MANAGEMENT EDUCATION CENTER</u>		
D. R. M. E. C. Summary of Activities	66	
P. D. Ivory	Quantification of Values for Decisions with Multiple Objectives	67
R. Sohlberg	Additivity of Allies	68
R. Sohlberg	Peacetime Registration, Conscription and Mobilization Planning in European NATO	70
<u>DEPARTMENT OF OPERATIONS RESEARCH</u>		
Chairman, Department of Operations Research	71	
J. F. Andrus	C-3 Laboratory Gaming Research	73
J. M. Wozencraft		
A. F. Andrus	HP-67 Program Development and Support	74
R. H. Shudde		
J. K. Arima	Research in Officer Manpower and Personnel Planning	75
P. R. Milch		
R. A. Weitzman		
D. R. Barr	C <sup>3</sup> Technology Evaluation and Transfer	77
G. T. Howard		
D. R. Barr	NPS Support of ACCAT Experiments	78
G. T. Howard		
G. G. Brown	Large-Scale Optimization	79
G. H. Bradley		
R. N. Forrest	FBM Vulnerability and Effectiveness Studies	81
A. F. Washburn		
R. N. Forrest	An Investigation of Localization and Tracking Procedures	82
D. P. Gaver	Modeling and Influence of Information on the Progress of Conflict or Combat by Mathematical and Computational Methods	83
D. P. Gaver	Research in Communication, Command, Control and Intelligence	84
J. M. Wozencraft		
R. R. Richards		
P. Moose		

	<u>PAGE</u>	
W. Hughes, Jr.	Quantity Verses Quality in Naval Ship Procurement Decisions	85
P. A. Jacobs	Probabilistic Models for Complex Systems	86
P. A. W. Lewis	Enhancements to the LLRANDOM II Random Number Generator Package	88
P. A. W. Lewis D. P. Gaver	Stochastic Analysis	89
G. F. Lindsay	NPS Support for the R&D Function of the Development Center	93
A. W. McMasters	Development of a Local Material Distribution Plan	94
A. W. McMasters	Stock Migration from NAVELEX to SPCC	97
D. E. Neil	Application of Color Coding in Tactical Displays in the S-3A	98
D. E. Neil	Study of the Ability of Voice Input Systems to Function in a Bilingual Environment	99
S. H. Parry J. K. Hartman A. L. Schoenstadt	Development of the Simulation of Tactical Alternative Responses (STAR) Model	100
G. K. Poock	Voice Input for Command and Control Systems	103
R. R. Read J. D. Esary	Review of SIDAC-C	106
R. R. Read	Study of Contour Construction Techniques Applicable to MX Valley Design Parameters	107
F. R. Richards J. Wozencraft D. P. Gaver P. Moose	Research in Communications, Command, Control and Intelligence	108
J. G. Taylor	Lanchester-Type Models of Warfare (Monograph)	109

	<u>PAGE</u>	
A. R. Washburn	Analysis of the Memoryless Tracker	111
A. R. Washburn	Expanding Area Search Experiments	112
A. R. Washburn	On the Tradeoff Between Drift and Variance	113
A. R. Washburn	Overlapping Pulse Trains	114
A. R. Washburn	Search for a Moving Target: The FAB Algorithm	115
 <u>DEPARTMENT OF NATIONAL SECURITY AFFAIRS</u>		
Chairman, Department of National Security Affairs		116
J. W. Amos, II R. H. Magnus	Effect of Islamic Culture on the Acceptance and Use of Western Cultural Items	118
M. Clough	Regional Cooperation in Southern Africa	119
D. C. Daniel K. L. Herbig	Battle of Wits: Synthesizing and Extrapolating from NPS Research on Strategic Military Deception	121
D. C. Daniel K. L. Herbig W. Reese R. J. Heuer T. R. Sarbin P. H. Moose R. G. Sherwin	Multidisciplinary Perspectives on Military Deception	122
R. Looney E. Laurance P. Frederiksen	The Economic Impact of Arms Transfers to Less Developed Countries with an Application to the Internal Economic Growth and Stability of Pre-Revolutionary Iran	124
R. H. Magnus F. M. Khairzada	Afghanistan: From Independence to Occupation	126
R. G. Sherwin	International and Intranational Events in Africa: Computerized Indications and Warnings	127

	<u>PAGE</u>	
R. H. S. Stolfi L. Ratley III	German Disruption of Soviet C <sup>3</sup> in the Opening Stages of Barbarossa	128
R. H. S. Stolfi	Lot Acceptance Verification Program, Airborne	129
J. Valenta D. Albright	Communist Countries and Africa	132
J. Valenta W. Potter	Soviet Decisionmaking for National Security	134
J. Valenta	Soviet Intervention in Afghanistan	137
J. Valenta	Soviet Policies Toward Hungary and Czechoslovakia	138
J. Valenta	The USSR and Cuba in the Caribbean Basin	139
D. S. Yost	French and Soviet Perspectives on Theater Nuclear Policy and Arms Control	140

DEPARTMENT OF PHYSICS AND CHEMISTRY

Chairman, Department of Physics and Chemistry	141	
F. R. Buskirk J. N. Neighbours J. N. Dyer W. Zeleny R. Spitzer	Stimulated Electromagnetic Shock Radiation Demonstrated Experiment	147
A. B. Coppens S. Trenchard	Experimental Study of a Saturated Parametric Array in Air	148
A. B. Coppens	Simple Speed of Sound Formulas for Neptunian Waters	149
E. C. Crittenden E. A. Milne A. W. Cooper G. W. Rodeback S. H. Kalmbach	Measurement of the Effects of Turbulence on Airborne Optical Projectors	150

	<u>PAGE</u>	
E. C. Crittenden E. A. Milne A. W. Cooper G. W. Rodeback S. H. Kalmbach	Optical Measurement of $C_n^2$ for Comparison with Predictions	152
D. E. Harrison K. E. Foley B. J. Garrison W. Winograd	Classical Trajectory Studies of Low Energy Ion Impact Mechanisms on Clean and Reacted Single Crystal Surfaces	153
R. L. Kelly	Spectroscopic Data Center Compilation of Atomic Energy Levels	155
R. L. Kelly	Spectroscopic Data Center Com- pilations of Near Ultraviolet Spectra	156
R. L. Kelly	Spectroscopic Data Center Com- pilations of Vacuum Ultraviolet Spectra	157
H. Medwin	Ocean Parameters Affecting Sound Propagation	158
P. H. Moose O. Heinz	Investigation of Geomagnetic Field Fluctuations on the Ocean Floor	160
R. A. Reinhardt G. F. Kinney	Internal Explosions Involving Reactive Metal Effects	162
J. V. Sanders A. B. Coppens	Finite-Amplitude Standing Waves in Real Cavities	163
J. V. Sanders	Hydrodynamic Noise Generated by Blunt Bodies	165
J. V. Sanders A. B. Coppens	Transmission of Acoustic Energy from a Fluid Wedge into a Fast Bottom	167
G. E. Schacher K. L. Davidson	Aerosols in the Marine Boundary Layer, Optical Extinction Effects	169
G. E. Schacher K. L. Davidson	Overwater Transport and Dispersion	170

	<u>PAGE</u>	
G. E. Schacher K. L. Davidson	Surface Truth Verification and Investigation of Stability and Wind-Wave Interaction Effects on the SEASAT Scatterometer	171
F. Schwirzke R. J. Taylor	Impurities in Tokamaks	172
F. Schwirzke	Plasma Surface Interaction	174
F. Schwirzke O. Biblarz	Study of Basic Mechanisms that Lead to Arcing	176
O. B. Wilson G. L. Sackman	Range Studies Program	177
O. B. Wilson, Jr. S. N. Wolf F. Ingenito	Underwater Acoustic Noise Due to Surf Phenomena	178

DEPARTMENT OF ELECTRICAL ENGINEERING

Chairman, Department of Electrical Engineering	179	
O. M. Baycura	Characterization and Suppression of Radio-Frequency Emissions from the TRS-80 Microcomputer	184
J. H. Duffin	Revision of the "Aircraft Engine Emissions Catalog"	185
A. Gerba, Jr. G. Thaler	NPS Sequential Steering Algorithm, Project Courageous Program	186
D. B. Hoisington	Effect of Soviet Airborne Jammers on Target-Detection Characteristics of U.S. Navy Radars	187
S. Jauregui	Automatic Voice Exploitation	188
S. Jauregui	Cryogenic Antennas for Shipboard Use	189
S. Jauregui	Marine Mobile Tactical Antenna Modeling	190
S. Jauregui	Narrowband and Wide Aperture HFDF Antenna Capability Against Short Duration Signals	191

	<u>PAGE</u>
S. Jauregui Operational HF Multicoupler Investigation	192
S. Jauregui W. Vincent Shipboard Noise and Interference Measurements	193
S. Jauregui Simulation of the AN/URD-10 and AN/SRD-19 Mastmounted VHFDF Antenna Systems	194
J. B. Knorr Communications System Studies	195
J. B. Knorr Millimeter Wave Transmission Media	196
P. H. Moose O. Heinz E. Crittenden Magnetic Monitoring Station at Chews Ridge	198
P. H. Moose J. Wozencraft D. P. Gaver F. R. Richards Research in Communications, Command, Control and Intelligence	201
M. Morgan M. Hamid Radar Target Identification Via Time-Domain Scattering Signatures	202
M. Morgan Recovery of Cross-Polarized Channels in Antenna Sidelobes	204
M. Morgan K. G. Gray SM-2 EMP Vulnerability Study	205
G. Myers SFSK Coding Methods	206
J. E. Ohlson K. Gray Jammer Analysis and Monitoring Subsystem (JAMS)	207
J. E. Ohlson SATCOM Signal Analyzer	208
J. E. Ohlson K. Gray Shipboard Microwave RFI	211
S. R. Parker Discrete Signal Processing Studies	212
S. R. Parker Reduced Order Characterization of Circuits and Systems	216

	<u>PAGE</u>	
J. P. Powers	Computer Aided Acoustic Imaging	219
J. P. Powers	Fiber Optics in Underwater Range Applications	221
J. P. Powers	Techniques of Acousto-Optical RF Signal Analysis	223
G. L. Sackman	Development of Acoustic Imaging System for Use in Torpedo Recovery	224
G. L. Sackman	Trace Function Beamformer for a Circular Array	225
R. D. Strum D. E. Kirk	Control Systems Design Studies	226
T. F. Tao	Development of Focal Plane Processing Techniques for Surveillance System Applications	227
T. F. Tao	Enhancement of Computing Power of 16 Bit Microcomputer by Using Microcomputer Compatible Array Processor	230
H. F. Titus	AEGIS Systems Research	235
H. A. Titus	Evaluation, Simulation and Analysis for the Crossbow Committee	236
L. A. Wilson	Multi-Source Track Management (MSTM)	237
L. A. Wilson	Ship Classification Techniques Using Tactical Sensors	238
J. M. Wozencraft N. R. Lyons R. Weissinger-Baylon	Battle Assessment for C3	239
J. M. Wozencraft D. P. Gaver P. Moose F. R. Richards	Research in Communications, Command, Control and Intelligence	240

	<u>PAGE</u>	
<u>DEPARTMENT OF METEOROLOGY</u>		
Chairman, Department of Meteorology	241	
C. P. Chang	Synoptic and Numerical Studies of Disturbances Over Tropical Oceans	244
C. P. Chang	Temporal and Spatial Variations of Large-Scale Tropical Flows	245
C. P. Chang R. T. Williams	Tropical and Monsoon Dynamics	246
K. L. Davidson J. Hojstrup	Analyses and Interpretation of White Cap, Surface Stress and Aerosol Data	249
K. L. Davidson	Development of Stability Dependent Surface Layer Aerosol	251
K. L. Davidson G. Schacher	Observational Studies on Marine Boundary Layer Processes	253
K. L. Davidson G. Schacher	Puff-Model Calculations of Smoke Obscurations	255
K. L. Davidson G. Schacher	Turbulent Determination of $C_n^2$	256
R. L. Elsberry R. W. Garwood	Modeling Upper Ocean Thermal Structure	258
R. L. Elsberry R. W. Garwood	Oceanic Thermal Response to Atmospheric Forcing	260
R. L. Elsberry	The Role of the Ocean in Extra- tropical Cyclone Evolution	262
R. L. Elsberry	Tropical Cyclone Studies	264
R. L. Haney	Numerical Modeling of Large- Scale Ocean Variability	266
K. M. Lau C. P. Chang	Tropical Large-Scale Ocean- Atmosphere Ocean Coupling	268
R. J. Renard W. van der Bijl	Application of Model Output Statistics to Forecasting Air/Ocean Parameters	269

	<u>PAGE</u>	
R. J. Renard D. F. Leipper G. H. Jung	Marine Fog Forecasting	271
R. J. Renard	Mesoscale Atmospheric Events-- Antarctica	273
R. T. Williams	Numerical Prediction Model Development	275
R. T. Williams	Numerical Simulation of Fronts Over Eastern Asia	277

DEPARTMENT OF AERONAUTICS

Chairman, Department of Aeronautics	279	
R. E. Ball	Aircraft Combat Survivability Studies	286
R. W. Bell	Investigation of the Potential for Mingling Tandemly Emitted Parallel Jets	290
R. W. Bell	V/STOL Aerodynamics	291
O. Biblarz J. L. Barto	Aerodynamic Stabilization of Gaseous Discharges	292
O. Biblarz F. Schwirzke	Study of Basic Mechanisms that Lead to Arcing	293
D. J. Collins	LDA Investigations	294
A. E. Fuhs	Aero-Optics for an Array of Laminar Flow Laser Turrets	295
A. E. Fuhs G. N. Vanderplaats G. A. Blaisdell S. E. Fuhs	Aero-Optics; Boundary Layer Control for Laser Beam Propagation	296
A. E. Fuhs G. A. Blaisdell	Beam Quality in Eximer Lasers	298
A. E. Fuhs	Combat Systems and Ship Arrangements	300

	<u>PAGE</u>	
A. E. Fuhs	Flow Control for an Airborne Laser Turret	301
A. E. Fuhs	Gun Launched Ramjet Guided Missile	302
A. E. Fuhs	Probe for Pressure Altitude Fuze for a Broad Jammer	303
T. H. Gawain	A Basic Reformulation of the Pipe Flow Stability Problem	304
T. H. Gawain O. Biblarz	Continuation of Study on ETD Power Generation	305
G. W. H. Hui	Unsteady Supersonic Flow Research	306
D. M. Layton	System Safety Software	307
G. H. Lindsey	Fatigue in Aircraft Structures	308
J. A. Miller O. Biblarz	Electrohydrodynamic Control of Fuel Injection in Aircraft Engines	309
D. W. Netzer	Holographic Study of Solid Propellant Combustion	310
D. W. Netzer	Particulate Behavior in Solid Propellant Rocket Motors	311
D. W. Netzer	Solid Fuel Ramjet Combustion	312
D. W. Netzer	Turbojet Test Cell Aerodynamics and Emission Levels	316
D. W. Netzer	Validation of Air Quality Assess- ment Model for Naval Air Operations	319
M. F. Platzer	Investigation of V/STOL Pro- pulsion Problems	320
L. V. Schmidt	Aircraft Flight Parameter Identification	321
L. V. Schmidt	Applied Research in Engineering Technology	322
L. V. Schmidt	Flight Mechanics Research	323

	<u>PAGE</u>	
R. P. Shreeve	Axial Compressor Flow Fields	324
R. P. Shreeve	Cascade Studies of Flows Through Compressor Bladings	325
R. P. Shreeve	Development of a Transonic Compressor Model	326
R. P. Shreeve	Multi-Stage Compressor Study	327
R. P. Shreeve	Transonic Compressor Investigation	328
 <u>DEPARTMENT OF OCEANOGRAPHY</u>		
Chairman, Department of Oceanography		330
R. W. Garwood	Studies of the Oceanic Planetary Boundary Layer	333
E. C. Haderlie	Biology of Stone and Wood Boring Animals in the Monterey Submarine Canyon and the Deeper Waters Off the Central California Coast	336
G. H. Jung R. H. Bourke C. R. Dunlap	Oceanographic Studies in Support of COMOCEANSYPAC (COSP)	337
C. N. K. Mooers	Point Sur Cold Wedge	339
C. N. K. Mooers	Synoptic Studies of Oceanic Fronts	341
R. G. Paquette R. H. Bourke	Studies of Oceanographic Condi- tions Near the Marginal Sea-Ice Zone, MIZPAC 80	343
E. B. Thornton T. P. Stanton	Acoustic Variability Experiment	345
E. B. Thornton	Field Measurements of Surf Zone Energetics	347
E. B. Thornton	Kinematics of Breaking Waves in the Surf Zone	349
E. D. Tranganza	Satellite and Synoptic Studies of Bio-Chemical Fronts in the Ocean	351

	<u>PAGE</u>	
J. B. Wickham S. P. Tucker	The Three-Dimensional Structure and Behavior of Mesoscale Ocean Features Associated With Their Remotely Sensed Surface Signatures	354

DEPARTMENT OF MECHANICAL ENGINEERING

Chairman, Department of Mechanical Engineering	356	
G. Cantin	Installation of GIFTS 5 at NPS	361
G. Cantin	Installation of IGT80 in the IBM 360 for the 4081 TEKTRONIX System	362
M. D. Kelleher	Development of a Shore Facilities Fire Protection Program	363
P. J. Marto R. H. Nunn	Exploratory Design and Development of Compact Naval Condensers	365
P. J. Marto G. Vanderplaats D. Salinas	FEM Analysis of an Internally Finned Rotating Heat Pipe	367
P. J. Marto	Improving the Heat Transfer Performance of Rotating Heat Pipes	368
P. J. Marto	Nucleate Pool Boiling from Enhanced Surfaces to Dielectric Fluids	369
T. R. McNelley K. D. Challenger	An Evaluation of the Through- Thickness Properties of HY-80 Plate	370
T. R. McNelley	Fracture Toughness Characterization of Thermomechanically Processed AISI 52100	372
T. R. McNelley	Thermomechanical Processing of Aluminum-Magnesium Alloys Con- taining High Weight Percentages of Magnesium	374
R. E. Newton	Finite Element Analysis of Cavitation	376

	<u>PAGE</u>	
R. H. Nunn	Ball-Obturated Spinning Tubular Projectile	377
P. F. Pucci	Effect of Cannister Geometry on Carbon Dioxide Absorption by Sodasorb	381
P. F. Pucci	Gas Turbine Exhaust Gas Stack Eductor Systems	382
D. Salinas	Advanced Composites Response Program	383
T. Sarpkaya	Hydroelastic Oscillation of Cylinders in Harmonic Flow	384
T. Sarpkaya	Impulsively-Started Flow About Submarine-Shaped Bodies	386
T. Sarpkaya	Low Airspeed Sensors	387
G. N. Vanderplaats	Development of a Library of Numerical Optimization Programs for Engineering Design	388
G. N. Vanderplaats	Optimum Design of Torsional Shafts Using Composite Materials	389
DISTRIBUTION LIST		391

## DEPARTMENT OF COMPUTER SCIENCE

The Research Program of the Computer Science Department supports and is supported by the NPS Computer Laboratories and the NPS Computer Center. An expanding research effort includes work in: hardware and software performance measurement methods and applications; optimization theory and applications; programming languages; compiler and operating system design, implementation and optimization; coding and information theory; microcomputer structures, software, and systems design; signal processing; computer graphics; design of real time systems; digital filters; and artificial intelligence.

The research program has permitted the development of a number of functional laboratories which support further research as well as instruction. These include 1) a microelectronics laboratory where microprocessors and single board computers are interfaced with a variety of equipment to become imbedded computers and 2) a microcomputer laboratory which includes a number of microcomputer development systems as well as a multi-user development system.

### INTERACTIVE GRAPHICS

The principal effort in the Graphics area has been the design and installation of hardware and software to support image processing instruction and research. This capability made possible the application of certain aspects of artificial intelligence to anti-submarine warfare programs by G. A. Rahe.

### CODING AND INFORMATION THEORY

R. W. Hamming is responsible for many fundamental results in coding and information theory. He is continuing this research. During 1979 he published a book on this subject. He is currently writing a book on elementary calculus.

### MICROCOMPUTERS

The work of U. R. Kodres has made this department a recognized center of expertise which has contributed to Navy-wide efforts to formulate standards for microcomputers. U. R. Kodres continues to explore the application of the interconnected networks of microcomputers. A multi-terminal microcomputer development system has been acquired to provide continuing support work in microcomputer languages and operating systems.

## LARGE SCALE OPTIMIZATION

G. Bradley and G. Brown are doing research on the solution of large scale networks, linear programs and integer programs. The research has been applied to major DoD projects including material distribution, personnel assignment and ammunition production.

## SIGNAL PROCESSING

The research area of G. A. Rahe continues to be concerned with anti-submarine warfare and computer graphics.

## COMPUTER NETWORKS, PERFORMANCE MEASUREMENT, AND SOFTWARE RELIABILITY

N. F. Schneidewind has done research on the development and application of computer networks; performance measurement techniques including the analysis of multiprogrammed computer performance; the relationship between program structure and error detection; the relationship between software design techniques and software maintainability; and the development of stochastic models for software error prediction.

## COMPUTER SECURITY

R. R. Schell is exploring the vulnerabilities in the internal security controls of current and projected computer systems. The effectiveness of vulnerability countermeasures, including the security kernel technology, is being addressed.

## OPERATING SYSTEMS

U. R. Kodres and R. R. Schell have continued research on operating system structures for effective use of multi-microcomputers in combat systems. Experimental configurations with the Intel 8086 and the Zilog Z8000 are being evaluated. A tightly interconnected system of Intel 8086 single board computer is evaluated for applications in the AEGIS weapons system which is presently under development for the Navy.

L. A. Cox and R. R. Schell are continuing work on secure operating system families for multiple processors using distributed kernel techniques.

## PROGRAMMING LANGUAGES

B. J. MacLennan is doing research on advanced methods for software development. This includes very-high-level languages, the structural analysis of programming languages and linguistic methods to aid the development of very large systems.

#### AUTOMATIC DESIGN OF ALGORITHMS

D. R. Smith is exploring issues of algorithm design by studying generic algorithm types and ways to represent knowledge about data structures. The results of these efforts are being used in the design of a system for automatically deriving algorithms from formal specifications.

#### COMPUTER ARCHITECTURES

The design and evaluation of modern computer architectures is central to the work of L. A. Cox. This effort includes the development of new design and evaluation tools as well as the actual design of high performance systems.



TIME-SHARING ON THE NPS COMPUTER LABORATORY  
UNIX SYSTEM ALLOWS RESEARCH IN A VARIETY OF  
AREAS AT THE FOREFRONT OF COMPUTER SCIENCE.

**Title:** Exploration of Performance Prediction Techniques for Advanced Computer Architectures

**Investigator:** Lyle A. Cox, Jr., Assistant Professor of Computer Science

**Sponsor:** NPS Foundation Research Program

**Objective:** Establish a testbed facility and develop efficient concurrent computer system design and evaluation techniques.

**Summary:** This research effort has resulted in the establishment of a 16 bit microprocessor development system within the Computer Science Department's Microprocessor Laboratory. This system is dedicated to the analysis and simulation of complex, advanced computer systems. Of particular interest are systems capable of significant concurrency or parallelism. Such units constructed to date have generally not lived up to their promise, being expensive and difficult to program. In order to understand how such systems respond and to be able to economically explore alternative configurations, design description languages and simulators have been implemented. These systems allow the designer/user to describe his hardware and software systems and then predict the performance of such a hypothetical system. Results indicate that the petri-net concurrent control system techniques being developed are capable of providing efficient, accurate and easily used models of large scale digital systems.

**Publications:** Lyle A. Cox, Jr., "Performance Prediction from a Computer Hardware Description," Proc. Fifth International Symposium on Computer Hardware Description Languages, October 1979.

Lyle A. Cox, Jr., "Predicting Performance of Communications Networks from Formal Descriptions," Proc. International Telecommunications Conference, May 1980.

**Theses  
Directed:**

D. L. Smith, "Method to Evaluate Micro-computers for Non-Tactical Shipboard Use," September 1979.

D. M. Stowers, "Computer Architecture Performance Prediction for Naval Fire Control Systems," December 1979.

S. C. Jennings and R. J. Hartell, "Petri-Net Simulations of Communications Networks," March 1980.

B. Hodgins, "Computer Evaluation thru Instruction Mix Sensitivity Analysis," (in progress).

**Title:** A Microprocessor Based Secure Archival Storage System

**Investigators:** Lyle A. Cox, Jr., Assistant Professor of Computer Science and Roger R. Schell, LTCOL, USAF, Assistant Professor of Computer Science

**Sponsor:** NPS Foundation Research Program

**Objective:** Specify, design and implement a verifiably secure archival storage system based on microprocessor technology. Such a system can serve as the "hub" of multi-level, secure network of computers sharing data and programs.

**Summary:** Security has been a continuing problem in developing and operating all types of computers, especially distributed networks of computers. Since these systems have the potential of allowing a wide audience of users to access sensitive data, they must be designed with caution. A technique for such system design, the "kernel technique," has been shown to be capable of providing the necessary security. Until recently, this technique could be implemented efficiently only on large computers. Recent advances in large scale integration microprocessors and "Winchester" disk storage system have made it possible to implement a secure archival system on a mini/micro scale. This scale is required for development of reliable distributed processing systems such as the "automated office" and the Navy's Shipboard Naval Administrative Processors (SNAP systems). Specifications, basic and advanced designs for this system have been completed and the project is currently in the early stages of implementing a demonstration testbed.

**Publications:** R. R. Schell and L. A. Cox, Jr., "The Naval Postgraduate School SECURE ARCHIVAL STORAGE SYSTEM: Part 1 - Design," NPS Technical Report NPS52-80-002, April 1980.

R. R. Schell and L. A. Cox, Jr., "A Secure Archival Storage System," Proceedings IEEE Computer Conference, September 1980.

Theses  
Directed:

J. S. O'Connell and L. D. Richardson,  
"Distributed Secure Design for a Multi-Microprocessor Operating System," Master's Thesis, June 1979.

A. R. Coleman, "Security Kernel Design for a Microprocessor Based Multilevel Archival Storage System," Master's Thesis, September 1979.

E. J. Parks, "The Design of a Secure File Storage System," Master's Thesis, December 1979.

E. E. Moore and A. V. Gary, "Design and Implementation of the Memory Manager for a Secure Archival Storage System," Master's Thesis June 1980.

S. L. Rietz, "An Implementation of Multiprogramming and Process Management for a Security Kernel Operating System," Master's Thesis, June 1980.

J. T. Wells, "Implementation of Segment Management for a Secure Archival Storage System," Master's Thesis, September 1980.

**Title:** Emulation of a Multi-Microcomputer Architecture for the SPY-1A Control Computer

**Investigators:** Uno R. Kodres, Associate Professor of Computer Science; Mitchell L. Cotton, Associate Professor of Electrical Engineering and Rudolf Panholzer, Professor of Electrical Engineering

**Sponsor:** Naval Sea Systems Command

**Objective:** To continue exploring the use of VLSI (very large scale integration) technology in the application of SPY-1A radar control.

**Summary:** The project is subdivided into hardware architecture development, interface to other systems components emulation, applications programs emulation, system's programming and performance analysis. We have completed hardware installation and are in the process of designing and implementing fiber optic interfaces to other computer components. We have completed preliminary performance analysis and are proceeding with detailed performance analysis and skeletal implementation of critical applications programs. Implementation of some interfaces (CoD, WCS) are nearly complete and others are starting. Overall emulation systems design is underway and its implementation is scheduled for September 1981.

**Publication:** Earl E. McCoy, "An ADA Language Model of the AN/SPY-1A Component of the AEGIS Weapon System," NPS Technical Report, NPS52-80-011, August 1980.

**Thesis  
Directed:** William D. Dilmore, Jr., "The INTEL MCS-86 as a Functionally Dedicated Microprocessor in AN/SPY-1A Radar Control," Master's Thesis, June 1980.

Title: Operating System Structures for Distributed Multi-Microcomputer Systems

Investigators: Uno R. Kodres, Associate Professor of Mathematics and Computer Science and Roger R. Schell, Assistant Professor of Computer Science

Sponsor: Office of Naval Research

Objective: Identify hardware and operating system software characteristics for effective use of multi-microcomputers in combat systems.

Summary: The recent development of Large Scale Integrated (LSI) general purpose computers (microcomputers) and the immediate future development of Very Large Scale Integrated (VLSI) systems (minicomputers) will radically change the economics and design concepts of dedicated computational systems. High performance computational systems can be built from concurrently operating multicomputer systems composed of commercially successful single board (in the future-single chip) computers. The purpose of this study: (1) identify operating system structures that will more effectively support combat systems applications, (2) provide architectural guidelines for hardware design to support the required operating system capabilities and efficiencies and (3) to identify the hardware and operating system features which enhance the implementation of secure systems composed of multi-microcomputers.

Conference Presentation: R. R. Schell, U. R. Kodres, H. Amir, J. Wasson, and T. F. Tao, "Processing of Infrared Images by Multiple Microcomputer System," Proceedings SPIE Annual International Technical Symposium, Vol 241, (28 Jul - 1 Aug 1980).

Theses  
Directed:

P. A. Myers, "Subversion: The Neglected Aspect of Computer Security," Master's Thesis, June 1980.

W. J. Wasson, "Detailed Design of the Kernel of a Real Time Multiprocessor Operating System," Master's Thesis, June 1980.

J. L. Ross, "Design of a System Initialization Mechanism for a Multiple Micro-Computer," Master's Thesis, June 1980.

G. B. Blanton, "Dynamic Linking in a Microcomputer Environment," Master's Thesis, September 1980.

Title: Advanced Methods for Software Development

Investigator: Bruce J. MacLennan, Assistant Professor of Computer Science.

Sponsor: NPS Foundation Research Program

Objective: Continued development of the theory and a practical methodology for advanced software development.

Summary: This project has investigated software development in the general context of large-scale system development. To this end, it has pursued the following questions:

What are the most effective methods of designing and developing complicated systems?

What are the systems and tools needed to support these methods?

What machine architectures are needed to support these tools?

The AY80 research program investigated a number of approaches to the development of software systems and found them all inadequate. To a large extent this can be attributed to a lack of a comprehensive viewpoint of systems development.

One result of the AY80 program has been the identification of a system development paradigm. This paradigm characterizes the system development process as a multistage, iterative process of generating successively more refined models of the goal system. In this connection, a taxonomy of models was developed which divides models into two classes (analog and scale) and a number of subclasses. One conclusion is that system development tools should aid in the production of models. Determining if one system is a model of another system involves determining if they share certain properties and it now appears that this will require the use of the "knowledge representation languages" or "conceptual networks" under investigation by natural language specialists. This will be an area of research in the AY81 program.

Conceptual networks are pertinent to two other aspects of this research. In order to determine what makes systems complicated the AY80 project investigated a number of methods for measuring the complexity of systems. The method which seems most successful measures complexity relative to a given conceptual network. The AY81 research will continue the development of this complexity measure and develop the mathematical treatment of conceptual networks in general.

Another use of conceptual networks is the "intelligent programming database." This is a system development tool that was briefly investigated in the AY80 program. The intelligent programming database facilitates the use of existing software modules and components by "understanding" the function of those modules in terms similar to programmers. That is, the modules are organized in a conceptual network.

One of the important accomplishments of the AY80 program was the construction of mathematical explications of systems and a number of related concepts. This has enabled a number of informal ideas about system development to be put on a firm mathematical basis. This, in turn, will facilitate the derivation of tools to aid the software development process. This mathematical systems theory will be pursued in AY81 for its own sake in addition to its applications to the software development problem.

In summary, the AY80 research effort has provided a much better understanding of the problem and of several related research directions to be pursued for a solution. The AY80 research effort produced a large quantity of notes which are currently being incorporated into three research reports, described below.

**Publications:**

B. J. MacLennan, "General Properties of Very High Level Languages," (technical report, in preparation).

B. J. MacLennan, "Structural Analysis of Programming Languages - Preliminary Results," (technical report, in preparation).

B. J. MacLennan, "Introduction to Programming with a Relational Calculus," (technical report, in preparation).

Theses  
Directed:

Four students are currently being directed in thesis work related to this project. Two are developing a retargetable compiler for Ada and two are investigating a method for automatically generating syntax-directed editors.

Title: Application of Auto-Instruction to Undersea Surveillance

Investigators: George A. Rahe, Professor of Computer Science and Cynthia E. Irvine, Assistant Professor of Computer Science

Sponsor: Naval Electronics Systems Command

Objective: To demonstrate improved manpower utilization and system performance by application of the methods of artificial intelligence expert systems to undersea surveillance.

Summary: A demonstration of an embedded tutorial was developed which introduces the new operator to the system, provides help during operations, and has refresher exercises for experienced operators. Since a sophisticated computer-based system must provide guidance and direction during operations the introduction and refresher are available at almost no cost.

This demonstration system is intended only to show that a tutorial system can be developed and deployed and does not purport to be a complete deployable system itself.

Thesis  
Directed: Patrick W. Flynn, "An Embedded Tutorial for a Tactical System," Master's Thesis, March 1980.



THE NPS COMPUTER LABORATORY WAS ONE OF THE FIRST  
FACILITIES IN THE NATION TO COMBINE RESEARCH IN  
COMPUTER GRAPHICS AND SIGNAL PROCESSING.

**Title:** Computer Security Vulnerability Evaluation

**Investigator:** Roger R. Schell, Assistant Professor of Computer Science

**Sponsor:** Central Intelligence Agency

**Objective:** Develop an improved understanding of the security risks resulting from the vulnerabilities of internal security controls of current and anticipated computers.

**Summary:** Computers are increasingly used to process sensitive and classified information; therefore, there is an increasing need to assess the attendant security risks. Previous projects have examined the weaknesses of the internal security controls of the contemporary computers, and a few current efforts, such as the government-sponsored Kernelized Secure Operation System (KSOS), are addressing such vulnerabilities. The project summarized here will evaluate the potential impact on system security of the vulnerabilities evident in the existing products of major manufacturers. In particular, the project will assess the risks that result from practical techniques to exploit these vulnerabilities in order to gain unauthorized access to computerized information. The project will also address the security value of various vulnerability countermeasures; the effectiveness of the security kernel technology and KSOS in particular will be specifically considered in this evaluation.

**Conference Presentations:** R. R. Schell, "Architectural Implications of Secure Operating Systems," Proceedings of MIMI '80 International Symposium, February 1980.

Title: Towards a Unified View of Search Techniques

Investigator: Douglas R. Smith, Assistant Professor of Computer Science

Sponsor: NPS Foundation Research Program

Summary: Necessary and sufficient conditions have been established for several kinds of representations of combinatorial problems under a certain model of dynamic programming. Problems have been found for which no dynamic programming representation can be used to generate all solutions. An algebraic model is being developed which allows the comparison (and generalization) of dynamic programming, divide and conquer, branch and bound, and greedy search techniques. Divide and conquer representations can be shown to be special cases of dynamic programs. Greedy representations can be shown to be special cases of branch and bound representations.

Publications:

D. R. Smith, "Representation of Discrete Optimization Problems by Discrete Dynamic Programs," NPS Technical Report NPS52-80-004, February 1980,

D. R. Smith, "On the Computational Complexity of Branch and Bound Search Strategies," NPS Technical Report NPS52-79-004, November 1979.

D. R. Smith, "Generalized Dynamic Programming and Divide and Conquer Algorithms," (technical report in preparation).

Seminars:

"Representation of Discrete Optimization Problems by Discrete Dynamic Programs," Operations Research Department Seminar, Naval Postgraduate School, June 1980.

## DEPARTMENT OF MATHEMATICS

The major areas of research in the Mathematics Department are Numerical Analysis, Optimization and Applied Statistics. A brief summary of the activities in each field is given as well as a summary of some of the miscellaneous research activities.

### NUMERICAL ANALYSIS

R. H. Franke has been continuing his studies of scattered data interpolation schemes. His work has resulted in a report on several methods for fitting a function of two variables. He also continues with T. Jayachandran their work on the Foutz Goodness-of-fit-test. Their results show that although Foutz's test does not dominate other tests in all instances, there are several cases where the Foutz test performs better than others. Their work appears in a technical report. A. L. Schoenstadt continues his work with R. T. Williams on numerical methods for weather prediction and has published two papers on that research.

### OPTIMIZATION

I. B. Russak has been doing research in constructing algorithms for constrained minimization problems, proving that these algorithms converge to a solution of the problem and establishing characteristics of the convergence rates. G. Owen has been continuing his work on Game Theory, principally in the area of theoretic analysis of group decision schemes for efficient decision making, and in the preparation of the second edition of his work, Game Theory.

### APPLIED STATISTICS

T. Jayachandran, together with H. J. Larson, is developing a new methodology for the determination of sampling intervals to be used with the spectrometric oil analysis program for prediction of potential failure of aircraft engines. A technical report has been issued and research continues. Jayachandran and Schoenstadt are performing statistical evaluation of a survey conducted of selected Navy shore facilities to locate asbestos-containing friable insulating material. P. C. C. Wang has been studying several areas of electro-optical technology with regard to threat forecasting in areas important to the Army. Through case studies of carefully selected hardware predictions of the Soviet ECM, reaction to several missile families through 1995 have been made.

## MISCELLANEOUS

A. L. Schoenstadt has been studying, along with S. H. Parry and J. K. Hartman, the modeling of Tactical Alternative Responses. He continues the development of the communications/Electronic Warfare portions of the model to represent selected command and tactical nets as well as appropriate non-communications emitters. In another area important to communications, H. M. Fredricksen has been investigating properties of binary sequences and techniques for their generation. A paper for journal publication has been submitted. Also, studies of irreducible polynomials over the field of two elements have been conducted. Selected irreducible trinomials to degree 60,000 will appear in a journal article. All irreducible pentanomials to degree 75 over the binary field appear in a paper submitted for publication. G. Latta continues to study singular integral equations. He has solved two previously unsolved problems. He continues to act as consultant to the School in the area of microprocessors both as a classroom aid and for students interactive use in their thesis research. M. D. Weir continues study of calculators and microprocessors. Two books will shortly appear on uses of the TI-59 calculator in business and engineering mathematics and in a study of the calculus. D. H. Trahan has been studying convergence of generalized Lambert series. His paper on the subject has recently appeared in Mathematics Magazine.



PROFESSOR H. M. FREDRICKSEN, PROFESSOR G. LATTA  
AND CAPT BOB HOLDAHL EXAMINING OUTPUT FROM  
THE NORTH STAR MICROPROCESSOR.

Title: Interpolation of Scattered Data

Investigators: R. Franke, Associate Professor of Mathematics, G. Nielson, Associate Professor of Mathematics, Arizona State University (supported by contract with Arizona State University)

Sponsor: Office of Naval Research

Objective: The objective was to investigate the mathematical basis for the "multiquadric method" due to R. L. Hardy.

Summary: The multiquadric method is a special case of a class of interpolation methods which minimize certain functionals involving the Fourier transforms of elements in a space of generalized functions (distributions). Investigation of this class of methods is presently continuing.

Publications: Will be forthcoming.

Title: Investigation of Foutz Test for Goodness-of-Fit

Investigator: R. Franke, Associate Professor of Mathematics

Sponsor: NPS Foundation Research Program

Objective: The objective was to investigate the properties of the Foutz goodness-of-fit test and to determine the distribution of the statistic for various sample sizes.

Summary: Extensive simulations comparing the Foutz test with the Chi squared test and the Kolmogorov-Smirnov test were performed. Pseudorandom deviates from various distributions were generated and the abilities of the three tests in rejecting the hypothesis that the sample came from a normal distribution were compared. These tests showed the Foutz test to perform better than the other two when the distribution is heavy tailed. The exact distribution for sample size form was determined. Monte Carlo simulations have been performed and approximate percentage points as a function of sample size are being determined in continuing work.

Publications: R. Franke and T. Jayachandran, "Empirical Investigation of the Properties of a New Goodness-of-Fit Test," Journal of the American Statistical Society, (submitted for publication).

R. Franke and T. Jayachandran, "A Study of the Properties of a New Goodness-of-Fit Test," NPS Technical Report, NPS53-80-003, May 1980.

Title: Gaussian Stationary Markov Processes-Prediction Problems

Investigator: Toke Jayachandran, Associate Professor of Mathematics

Sponsor: NPS Foundation Research Program

Objective: Construct prediction intervals for future observations of a first-order Gaussian Markov Process.

Summary: First-order Gaussian Markov Processes (GSM) are used extensively in modeling certain economic and meteorological phenomena. It would therefore, be of interest to obtain a statistical prediction interval for the next future observation based on all the past or observed data. Such a prediction interval has been constructed using half of the observed data as conditioning variables. The properties of the interval as the parameters of the GSM process vary have been extended to obtain prediction intervals for future observations in a linear trend model. A technical report incorporating the results has been published and a paper is under preparation for submission to a technical journal for publication.

Publications: Toke Jayachandran, T. S. Murthy, "A Prediction Interval for a First Order Gaussian Markov Process," Technical Report NPS53-80-002, April 1980.

Thesis Directed: T. S. Murthy, "Prediction Intervals for First Order Markov Processes," Master's Thesis, September 1979.

Title: JOAP Analysis-Determination of Sampling Intervals

Investigators: Toke Jayachandran, Associate Professor of Mathematics, H. J. Larson, Professor of Operations Research

Sponsor: Kelly Air Force Base

Objective: Develop new methodology for determination of sampling intervals.

Summary: The Joint Oil Analysis Program (JOAP) is a tri-service standardized program to monitor equipment such as aircraft engine wear condition through periodic spectrometric analysis of oil samples. A sharp increase of a wear metal such as iron could be an indication of an impending part failure. When a potential is identified the oil sampling frequency is increased and as soon as the wear metal-content level exceeds a threshold value the aircraft is grounded. The determination of intervals in which samples are taken at regular frequency, increased frequency and the specification of a threshold value are called sampling interval problems.

The properly used method has been developed based on pooled historical data on all equipment of the same type and combining all failures of different parts of the equipment. This has not worked too satisfactorily because of the pooling over equipment and failures of different parts. The objective of this sponsored research project is to develop new methodology based on a single equipment historical record that gets updated as new data is obtained. This is to be based on the assumption that each piece of equipment has its own unique "signature".

A new methodology has been developed and has been tested on a preliminary set of data and the indications are that this would improve on the existing procedure. A preliminary draft report has been

approved by the sponsor and a final technical report is nearing completion. It is expected that the project will be extended so that the methodology can be tested on a more extensive set of data and then to suggest an implementation plan for JOAP.

Publication: Toke Jayachandran, H. J. Larson, "Methodology for Determining Sampling Intervals," NPS Technical Report, NPS53-81-001.

**Title:** A Conjugate Gram Schmidt Algorithm in Constrained Minimization Problems

**Investigator:** I. Bert Russak, Associate Professor of Mathematics

**Sponsor:** NPS Foundation Research Program

**Objective:** To develop a version of the Conjugate Gram Schmidt (CGS) algorithm for constrained minimization problems. Also to determine the convergence characteristics of the algorithm.

**Summary:** Real world problems in constrained optimization occur very frequently in military applications, e.g., optimizing with respect to time to intercept, the parameters of a missile interceptor system subject to constraints on its motion. The topic of this project is to develop a numerical algorithm which solves such problems.

The CGS algorithm described in (1) applies to unconstrained minimization problems in this project. It is intended to extend that method so that it applies to the constrained minimization problems of minimizing a function  $f(x)$  subject to the inequality and equality constraints

$$g_{\alpha}(x) \leq 0 \quad \alpha = 1, \dots, m', \quad g_B(x) = 0 \quad B = M' + 1, \dots, m$$

This also includes proving that the method converges and establishing characteristics of its rate of convergence.

The method of attack is to use a sequence of subproblems. These subproblems are then solved by a version of the CGS method. It is to be shown that the resulting sequence of solutions converges to the solution of the problem stated above.

This is a continuous project and the items thus far accomplished include: a) definition of the form of the approximating subproblem to use and b) definition of the particular modification to CGS to use in solving each subproblem.

Publication:

I. B. Russak, "Convergence of the Conjugate Gram Schmidt Method," to appear in Journal of Optimization Theory and Applications, Vol. 33, No. 2, February 1981.

Title: Technical Assistance in Asbestos Abatement Estimation

Investigator: Arthur L. Schoenstadt, Associate Professor of Mathematics

Sponsor: Civil Engineering Laboratory (CEL)

Objective: Provide technical assistance to CEL in the statistical evaluation of a survey conducted of selected Navy shore facilities to locate asbestos-containing friable insulating material (FIM).

Summary: Survey responses from approximately 2,100 Navy shore facilities were analyzed. Estimates were developed on the expected frequency of occurrence of asbestos-containing FIM, and on the mean values of the square footage and condition of such material. These values were forwarded to CEL to be used in cost estimates for asbestos abatement projects.

Publication: A. L. Schoenstadt, "Observed Statistics on the Occurrence of Friable Insulating Material and Pipe Lagging," report forwarded to CEL. (Copies should be requested from Mr. E. Lory, Code L-52, CEL.)

Title: Automation Technology and Technological Threat Forecasting Methodologies

Investigator: Peter C. C. Wang, Associate Professor of Mathematics and National Security Affairs

Sponsor: Office of Missile and Electronic Warfare

Objective: To continue development of theory and applications in the area of technological threat forecasting methods.

Summary: The research program has continued on several fronts. The area of Automation with implementations shall have my center attention during this coming year. As far as actual Weapon Systems are concerned, we shall look into systems representing threats in the long-range time frame, such as CM and CCM of the Soviets, Top attack systems toward ground mobile forces.

There shall be at least 10 significant theses topics with data provided by Research Sponsors ready for new students to participate in research.

Theses Directed:

John H. Reynolds, "PGM Countermeasures Op. Modeling and Appl.," Master's Thesis, December 1979.

L. P. Casalegno, "Soviet Airborne Noise Deception Electronic," Master's Thesis, March 1980.

R. Randolph, "Long-Range Surface to Surface Soviet Cruise Missiles," Master's Thesis, March 1980.

B. DeAses and Robert Uhl, "Chemical Countermeasures/EM Detection," Master's Thesis, March 1980.

Richard Myers, "Long Range ASW Aircraft-A Reassessment Study," Master's Thesis, March 1980.

M. J. Bayer and S. R. Christensen, "Soviet Communication Satellites and Forecast," Master's Thesis, June 1980.

Charles Cook and C. E. McKeldin, "Soviet ASW Diesel Attack Submarine Studies," Master's Thesis, June 1980.

Brent Worms and Don Thackery, "An Analysis of Soviet 53cm Electric Anti-Ship Torpedos and Forecast of Future Generation Weapons," Master's Thesis, August 1980.

## DEPARTMENT OF ADMINISTRATIVE SCIENCES

The Administrative Sciences Department is the Naval Post-graduate School's organizational unit responsible for academic programs designed to educate officers and DOD civilians in a variety of functional management specialties. As such, it is a large, multi-disciplinary department with diverse research projects oriented to support management tasks within the Navy and the Department of Defense. For ease of exposition the research program may be divided into the following six (sometimes overlapping) areas of research concentration: Systems Acquisition Management, Organizational Sciences, Health Care Delivery Systems Management, Financial/Resource Management, Information Systems and Technology Transfer. The past year's focus of the specific research projects in these areas is summarized in the following paragraphs.

### SYSTEMS ACQUISITION RESEARCH

C. R. Jones continued his research into the behavior of defense contractors and the peculiarities of this industry structure for defense contracting. D. C. Boger continued his examination of aerospace industry profitability in an attempt to determine the extent and nature of profitability differences between aerospace and other industries. In addition, Professor Boger began an investigation of the relationship of internal firm organization and financial performance. M. B. Kline continued his research in systems engineering and the systems acquisition process areas. P. Ein-Dor completed his studies of computer software conversion costs and methodologies to predict them. David Lamm and Ronald Schill examined the relationship between the strategic planning process and issues which give rise to its use in defense contracting firms. Roger Evered developed a number of case studies in the defense contracting and public policy areas.

### ORGANIZATIONAL SCIENCES

J. D. Senger continued his exploration of the relationship among personality test scores, academic performance and the career success of Naval Officers. R. Elster continued his research involving the design and evaluation of a "counter-attrition" experiment at a Naval Training Center. Professor Elster also investigated and analyzed the military service performance of General Educational Development certificate holders. C. K. Eoyang, in conjunction with P. Butler, R. McGonigal and R. T. Harris, continued their research in the Human Resources Management area. The overall goal is the application of Behavioral Sciences technologies to improve

organizational effectiveness and to increase productivity through extensive field investigation and contact. M. R. Louis continued her research into the dynamics of career transitions, by developing a theoretical framework describing individuals' coping processes during such transitions, formulating a taxonomy of such transition situations, and evaluating alternative organizational practices to facilitate the transition. R. A. Weitzman began development and testing of sequential aptitude testing applications for recruit selection and assignment. In addition, Professor Weitzman continued his research into development of predictive techniques useful in manpower/personnel research. J. K. Arima, in conjunction with a number of colleagues in the Department of Operations Research, continued the research program in Officer Manpower and Personnel Planning, the object of which is to develop a dynamic, interactive computer model to assist in such planning, and in the evaluation of related policy. Roger Evered began development of a theoretical framework to synthesize the variety of planning activities evidenced in public and private organizations.

#### HEALTH CARE DELIVERY SYSTEMS AND MANAGEMENT

D. R. Whipple, in conjunction with R. T. Harris, G. Thomas and K. Kocher continued the multi-year effort to develop an algorithm to estimate the appropriate mix of physician and non-physician providers required to staff primary care clinics in military hospitals. In addition, Professors Whipple, Thomas and Kocher continued their investigation into the feasibility of a non-workload-based efficiency measure for use in the military hospital's budgetary process. Professor Whipple and Professor Kocher, in conjunction with Dr. John Hoag at the Jet Propulsion Laboratory, also continued their research into the operational meaning of "Health Care as a Right" and the implications for structuring a National Health Insurance program.

#### FINANCIAL/RESOURCE MANAGEMENT RESEARCH

S. S. Liao researched the feasibility of using the method of indirect cost allocation as practiced in the private sector to determine the full cost of public services and to measure governmental efficiency. J. M. Fremgen and Professor Liao collaborated on a study of common cost allocation practices for the National Association of Accountants. K. J. Euske continued to expand his research on behavioral effects generated by the budgetary process. In particular he studied the effects of the relative degree of differentiation and integration of management control systems upon their effectiveness and efficiency. R. A. Bobulinski continued his work relating organizational management principles to practical comptrollership functions. E. A. Fincke and W. H. Skierkowski

continued development of text material for the Financial Management courses. D. C. Boger continued his research into the nature of private and social costs experienced in inland water and rail transportation. In addition the work cited by Professor Boger and by Professor Jones under systems Acquisition Research, and that by Professor Whipple under Health Systems are a part of this research area. R. D. Little completed a project analysing the socio-economic characteristics of the All Volunteer Force.

#### INFORMATION SYSTEMS

A. W. McMasters continued his investigation of possible internal criteria which the Naval Electronics System Command could use to determine the timely transfer of inventory control to the Ship's Part's Control Center of the Naval Supply Systems Command. He also completed development of a local delivery system for the Oakland Naval Supply Center. N. F. Schneidewind continued his research in the areas of software engineering and management, specifically studying methods to improve system and software specification processes so that the resulting software can be more easily maintained, with specific application to the TRIDENT program. N. R. Lyons studied the information gathering behavior of individuals, manipulating the environment of an economic computer game to examine the effect of a variety of information and resource conditions as well as the individual's propensity for risk-taking behavior. R. Weissinger-Baylon continued his research on the function of visual mental imagery in problem solving and decisionmaking.

#### TECHNOLOGY TRANSFER MANAGEMENT RESEARCH

J. W. Creighton continued his research on the technology transfer process. The focus of his analysis is on human interaction with emphasis on the utilization of the process and concepts of technology transfer by managers, whose understanding and relationship to individuals in the organization can highly influence the transfer of technology from source to user and is considered to be one of the prime responsibilities of a successful manager. He expanded his research to treat the need for acquiring skills for innovating in the development of executive capabilities. Additional emphasis is on the acceleration of the rate by which results of research are utilized, and the resultant benefits for the national economy.

**Title:** Industry Structure and Strategy: The Aerospace Industry

**Investigator:** Dan C. Boger, Assistant Professor of Economics

**Sponsor:** NPS Foundation Research Program and Office of Naval Research

**Objective:** Determine the influence of internal firm organization upon the performance of the individual enterprise using the aerospace industry as an example. This is the start of a longer term project which will examine all sectors of this industry, as well as other industries, from the same perspective.

**Summary:** Research has been directed specifically at the major aircraft and airframe manufacturers. Application of the Williamson paradigm to this sector of the aerospace industry has yielded the testable hypothesis that the financial performance of a sample of firms in this sector is a statistical function of the internal organization of the firm. Preliminary results are most encouraging, indicating a substantiation of the Williamson hypothesis for those firms for which data is currently available. The final model and analysis will occur upon completion of the data set concerning internal firm organization for the entire sample period for all firms.

**Publication:** A technical report is in progress.

**Thesis  
Directed:** R. W. McCabe, "The Aircraft Industry Since World War II: An Internal Organizational Approach," Master's Thesis, to be completed for March 1981 graduation.

Title: A Statistical Examination of Profitability  
in the Aerospace Industry

Investigator: Dan C. Boger, Assistant Professor of Economics

Sponsor: Navy Center for Acquisition Research

Objective: To examine profitability within the aerospace industry and to subject alternative profitability measures to statistical tests in order to determine the extent to which these measures differ from similar measures for all manufacturing industries, similar commercial industries, and rate-of-return regulated industries.

Summary: Research to date has utilized profit-center data available from the Profit '76 report produced for the Deputy Secretary of Defense. Major results of the analysis indicate, first, that there is no significant difference in return on assets between either defense or commercial profit centers and the FTC average for all manufacturing firms. Second, there is a significant difference in return on sales between defense or defense-common and the FTC average. Third, there is no significant difference in return on sales between commercial or commercial-common and the FTC average. Comparisons with other benchmarks remain to be completed.

Publication: D. C. Boger, T. Jayachandran, C. R. Jones and M. G. Sovereign, "The Status of the Aerospace Industry: A Perspective," NCAR Working Paper 80-2, May 1980.

Title: Studies in Workloading, Maintenance Cost Allocation, and Maintenance Effort Planning

Investigator: J. W. Creighton, Professor of Administrative Sciences

Sponsor: Pacific Missile Test Center

Objective: To determine an acceptable ratio between maintenance costs and capitalization of equipment and facilities

Summary: Costs upon which to base operating plans for the missile test range had not been previously collected. A prior study in FY-79 had identified certain areas for which historical costs should be stored. This year's effort further identified the pertinent cost data which should be accumulated, and outlined ways by which these data could be used for missile range management. Collection of data has commenced.

Thesis  
Directed: R. Jensen, "Maintenance Cost Control at the Pacific Missile Test Center," Master's Thesis, September 1980

Title: Symposium Proceedings and Technology Utilization Enhancement

Investigators: J. W. Creighton, Professor of Administrative Sciences and J. A. Jolly, Professor California State University, Sacramento

Sponsor: Naval Material Command

Objectives: In May 1979, a symposium was conducted for the Material Command in Washington, D.C. on Utilization of Research Results. NAVMAT had requested that effort in FY-80 be directed toward:

- a. Prepare and edit for publication the proceedings of the 1979 symposium.
- b. Continue the research effort reported in the proceedings with emphasis on the evaluation of efforts to plan for the use of research results at an early stage of a project.
- c. Aid in the Naval Facilities Engineering Command Technology Utilization of Technology Effort with an objective to apply some of the beneficial methodology to other Navy research activities.
- d. Perform miscellaneous studies in support of the Federal Laboratory Consortium.

Summary: The proceedings of the Symposium have been published as Technology Transfer; Research Utilization and User Stimulation by NAVMAT NAVFAC and the Postgraduate School, Fall 1980.

Further research has been reported under various headings in Thesis studies at the Postgraduate School.

Aid to the Facilities Engineering Command Survey resulted in the publication of NPS Technical Report, NPS54-80-011.

Research effort to assist other laboratories is under way but no publications have resulted to date from Navy laboratories. An effort to assist the South West Forest and }

Range Experiment Station, U.S. Forest Service has resulted in publication now under editing at the Forest Service.

Reports (unpublished) were prepared for the Federal Laboratory Consortium to evaluate the feasibility of a Technology Transfer Research Center. These have contributed to the establishment of a National Center at the Department of Commerce.

**Publications:**

J. W. Creighton and J. A. Jolly, Technology Transfer; Research Utilization and User Stimulation, Published by NAVMAT, NAVFAC and NPS, Fall 1980.

J. W. Creighton, M. G. Akin, G. P. Nix, G. R. Jefferson, J. A. Jolly, and F. H. Early, "Evaluation of the Utilization of Research and Development Results Naval Facilities Engineering Command," NPS Technical Report, NPS54-80-011, September 1980.

Title: Usage and Effectiveness of the Navy Civil Engineering Laboratory R&D Effort

Investigator: J. W. Creighton, Professor of Administrative Sciences, J. A. Jolly, Professor Cal. State University of Sacramento

Sponsors: Naval Facilities Engineering Command, and Naval Material Command

Objectives: As a continuing project the primary objectives during 12 prior years has been to enhance the effectiveness of Naval Facilities Engineering Command R&D activities. The primary specific objective of this years work, was to evaluate the effectiveness of efforts over a 12 year space to transfer Civil Engineering Laboratory research results into useful products or methods.

Summary: A questionnaire was administered to Civil Engineering Command Personnel (Military and Civilian) to question them as to the usefulness of Laboratory assistance, laboratory reports and the response to field generated needs.

The response from respondents indicated a very high opinion of laboratory effort and responsiveness to field needs. This in contrast to a similar survey's results which indicated that in 1967 the opinion of field people of the Laboratory effort was extremely negative.

This change from very negative to very positive indicates that the technology transfer effort engaged in by the Laboratory, NAVFAC R&D headquarters, and the Postgraduate School have been highly beneficial.

Publications: J. W. Creighton, and J. A. Jolly, "Evaluation of the Utilization of Research and Development Results by the Naval Facilities Engineering Command," NPS Technical Report, NPS54-80-011, September 1980.

Title: Evaluation of the R&D CREDO at RTC Great Lakes

Investigator: R. S. Elster, Professor of Administrative Sciences

Sponsor: Office of the Chief of Chaplains

Objective: Determine whether or not CREDO reduces first-term enlisted attrition.

Summary: The first year of research (1980) led to the establishment of comparable experimental and control groups, and to the development of a tracking procedure and data bank. During FY81, first-year attrition from the Navy will be computed for the R&D CREDO groups and for control groups.

Publication: R. S. Elster, "Evaluation of the R&D CREDO: Progress Report II," July 7, 1980 (Unpublished Report).

Thesis  
Directed: S. G. Hawkins, "RTC CREDO: Initial Assessment", Master's Thesis, June 1980.

Title: Relationships Between Educational Credentials and Military Performance Criteria -- An Evaluation of the General Educational Development (GED) Certificate

Investigator: R. S. Elster, Professor of Administrative Sciences

Sponsor: National Institute of Education

Objective: Elucidate the relationships among civilian educational experiences and performance during military service.

Summary: This study uses DOD data files to compare high school diploma graduates, GED certificate holders, and other non-high school graduates on behavioral and performance criteria gathered during initial tours of active duty in the military.

Thesis  
Directed: G. J. Carrier, "Success of Job Corps Personnel Entering the Military", Master's Thesis, June 1980.

**Title:** Human Resource Management System: Research and Support Project

**Investigator:** C. K. Eoyang, Professor of Administrative Science, and Reuben T. Harris, Associate Professor of Administrative Science

**Sponsor:** Naval Military Personnel Command

**Objective:** To provide continuing research, analysis, training, and consultation support to the U.S. Navy's Human Research Management Support System (HRMSS) at both field and staff levels.

**Summary:** Since FY 79, numerous activities were conducted under this project in support of the above objective. In response to a request for assistance in developing a plan for revitalizing the HRMSS, a "report" was written which detailed a series of suggested actions which might be undertaken to achieve such a goal. Two long-term demonstration projects were undertaken which the goal of improving the capability of HRMC's and documenting the strategy and outcome of those efforts. The two project sites are HRMC-San Diego and HRMC-Pearl Harbor. Also NPS faculty have delivered training activities at HRMC's and HRMD's at Pearl Harbor, San Diego, Alameda, Norfolk, Charleston, Washington, D.C. and NPS. NPS faculty planned and managed the Military HRM Symposium held at NPS (November 1979) and produced the published Proceedings of that conference. NPS faculty have served as a primary vehicle for knowledge and information developed and available in the non-military areas to be transferred to Navy policy and operational units. Finally, NPS faculty designed and delivered a two-week Advanced OD Course for HRMC OD Specialists.

**Publication:** R. T. Harris, "Report on Advanced Human Resource Management Training Program," NPS Technical Report, NPS54-80-08, January 1980.



ASSOCIATE PROFESSOR CARSON EOYANG, ASSOCIATE  
PROFESSOR REUBEN HARRIS AND CAPT PHILIP BUTLER  
CONSULTING WITH RESEARCH SPONSOR, CAPT, DON  
MARTIN, USN (DIRECTOR OF HUMAN RESOURCE MANAGE-  
MENT AND PERSONAL AFFAIRS DEPARTMENT).  
(INDIVIDUALS LISTED FROM RIGHT TO LEFT).

Title: An Analysis of the Factors Affecting the Efficiency and Effectiveness of Management Control Systems

Investigator: Kenneth J. Euske, Assistant Professor of Administrative Sciences

Sponsor: NPS Foundation Research Program

Objective: The project is being used to study the effects of the relative degree of differentiation and integration of management control systems upon the effectiveness and efficiency of those systems.

Summary: Progress is continuing on the Foundation research project. The specific management control systems and factors within those systems that will be investigated have been identified. The organizations that will be studied are now being selected. It is anticipated that the visits to and interviews with the sample organizations will be conducted during the fall and winter quarters.

Title: Development of Public Policy Case Materials

Investigator: Roger Evered, Associate Professor of Administrative Sciences

Sponsor: Rand Corporation/Duke University

Objective: Develop public sector case materials that highlight issues of public policy, that can be made available to other public sector schools.

Summary: Very few useable policy cases are available from the public sector, unlike the private sector. Funds were provided to NPS by the Rand/Duke sponsorships under their Public Policy Materials Development Program. Three such cases were developed from student theses together with formal teaching notes.

Publications:

R. Evered and C. Welterlen, The Surface Effect Ship Program, Rand Corporation, 1980.

R. Evered and F. Easton, Cost Estimating for the Guided Missile Frigate, Rand Corporation, 1980.

R. Evered and J. Vellis, Escalation Clauses in Shipbuilding Contracts, Rand Corporation, 1980.

Thesis  
Directed:

D. Karnesky, "Case Writing for Military Organization," Master's Thesis in progress.

Title: Futures Planning in Organizations

Investigator: Roger Evered, Associate Professor of Administrative Sciences

Sponsor: NPS Foundation Research Program

Objective: Development of theoretical framework for synthesizing the variety of planning activities evidenced in private and public sector organizations. Develops a typology of planning types and functions, and contrasts private and public sector planning.

Summary: A variety of planning conceptualizations have been collected from published literature and from interviews with selected public and private sector managers. The work is about half completed.

Publications: A 200 page book for the Little, Brown and Co. in "Policy and Planning" series is in process.

R. Evered, Futures Planning in Management: Bibliography, Council of Librarian, 1979.

R. Evered, "Management Education for the Year 2000," to appear in a book entitled Developing Managers for the 80's, ed. C. Cooper, Macmillian, 1980.

R. Evered, "Consequences of and Prospects for Systems Thinking in Organizational Change," in Systems Theory for Organizational Development, ed. T. Cummings, John Wiley, 1980.

Title: The Allocation of Corporate Indirect Costs

Investigators: James M. Fremgen, Professor of Accounting,  
and Shu S. Liao, Associate Professor of  
Accounting

Sponsor: National Association of Accountants

Objectives: To determine current business practices  
with respect to the allocation of corporate  
indirect costs and the reasons for these  
practices.

Summary: Despite theoretical argument against in-  
direct cost allocation, most companies  
responding to the questionnaire survey  
reported allocating indirect costs for some  
purpose. The distinction between direct and  
indirect cost is not as clear-cut as  
theorists suggest. Besides traceability,  
there are several factors affecting the  
classification of corporate expenses as  
direct or indirect costs. The selection  
of allocation bases was somewhat arbitrary  
and did not reflect the criteria the  
respondents identified. The reasons for  
allocating indirect costs were behavioral  
in nature in most cases.

Publication: The final report has been submitted to the  
sponsor for review. If approved, the re-  
port will be published as a research mono-  
graph and a brief summary will be published  
as an article in Management Accounting.

**Title:** Strategic Acquisition/Resources Market Planning

**Investigators:** David V. Lamm, Assistant Professor of Acquisition, Ronald Schill, Adjunct Professor of Administrative Sciences

**Sponsor:** NPS Foundation Research Program

**Objective:** The objective of this research is to examine specific issues within the defense industry which shape the nature of strategic planning emerging within prime contractor companies and to develop an empirical model explaining and analyzing the issues which (1) give rise to the increased need for strategic management of the corporate procurement function in these companies, and (2) are contained within the strategic planning process of the procurement function as it is occurring. The model will attempt to contrast and provide a taxonomy of issues which are specific to the defense industry and the Defense Department as the prime customer.

**Summary:** The research will have significant information to provide for potential changes in acquisition policy, source evaluation criteria, as well as major opportunities for initiatives involving changes in technological and materials/components long-range acquisition planning by contractors. Several companies provided liberally of detailed information on strategic planning procedures which will be of major benefit to defense contractors who are less sophisticated in conceptual/managerial planning techniques. Although all companies are rather weak in strategic planning as it pertains to procurement/technology planning, most expressed considerable interest in receiving the conceptual assistance and direction to improve this which the proposed prescriptive chapter will contain. The study also indicates significant capital risk taking by contractors beyond contract coverage in order to support contract effort, a factor which was not expected among the DOD managers interviewed.

**Publication:** Report in Preparation

Title: Measuring the Efficiency and Effectiveness of Governmental Activities

Investigator: Shu S. Liao, Associate Professor of Administrative Sciences

Sponsor: NPS Foundation Research Program

Objective: To study the feasibility, conceptually and empirically, of using the method of indirect cost allocation as practiced in the private sector to determine the full cost of delivering public services and measure the efficiency of governmental activities.

Summary: A framework is developed for disaggregating governmental entity activities until the element of activities is measurable. Four basic layers -- planning element and sub-element, program and subprogram, activity, and task are used to disaggregate activities for cost determination purposes. The disaggregated governmental activities resemble those of the production department of business organizations. Activities can then be classified into line function and support function. The costs of operating support function are then allocated to the line functions. The costs so accumulated become the basis for governmental activity efficiency measurement.

Conference Presentation: Shu S. Liao, "Performance Evaluation: A Missing Link in Public Sector Financial Management Education," Proceedings of the Third National Conference on Teaching Public Administration, May 1980.

Publication: A manuscript is in preparation for submission to Public Administration Review.

Theses Directed: Grant G. Hintze, "Allocation of Allowable Indirect Costs in Management of Commercial/Industrial Activities," Master's Thesis, September 1980.  
B. R. Benroth and R. F. Fremont, "Overhead Cost Accounting Model for Municipalities," Master's Thesis, in progress.

**Title:** The First Years Out Study -- Career Transitions: Facilitating Recruit Adaptation

**Investigator:** M. R. Louis, Assistant Professor of Administrative Sciences

**Sponsor:** NPS Foundation Research Program

**Objective:** This study is part of a continuing research program the overall aims of which are to expand our understandings of career transitions. The characteristics of transition experiences, the cognitive and behavioral processes by which individuals cope with transitions, organizational practices for facilitating transitions, and the cultural features of organizational life involved in the acculturation of new members have been investigated to date.

**Summary:** The research program has resulted in the formulation of: a model of the cognitive processes by which individuals cope with transition experiences; a conceptual framework distinguishing among features of transition experiences; and a typology of career transition situations to aid in analyzing particular transition situations and integrating research across transition settings. A comparative analysis of alternative organizational practices aimed at facilitating transitions of new members was conducted. Cultural aspects of organizational life which play a major role in new member acculturation have been described and methods for empirical investigation of culture in organizations have been outlined.

**Publications:** M. R. Louis, "Career Transitions: Varieties and Commonalities," Academy of Management Review, 5, 3, July 1980, 329-340.  
M. R. Louis, "Surprise and Sense Making: What Newcomers Experience in Entering Unfamiliar Organizational Settings," Administrative Science Quarterly, 25, 2, June 1980, 226-251.

M. R. Louis, "Socialization and Recruitment in Organizations: A Clash between Homeostatic and Adaptive Systems," Proceedings, Society for General Systems Research, January, 1980 (also presented at the 1980 Annual Meetings of the society in San Francisco).

M. R. Louis and R. Evered, "Alternative Perspectives in the Organizational Sciences: Inquiry from the Inside and Inquiry from the Outside," to appear in the Academy of Management Review.

M. R. Louis, "Organizations as Culture-Bearing Milieux," to appear in a book edited by Peter Frost on Organizational Symbolism, University of Chicago Press, 1981.

M. R. Louis, "Toward an Understanding of Career Transitions," in Work, Family and The Career: New Frontiers in Theory and Research, by C. B. Derr, Praeger Press, 1980.

Conference

Presentations:

M. R. Louis, "Learning the Ropes: "What Helps New Employees Become Acculturated?" Presented at the Annual Academy of Management Meeting, Detroit, August 1980.

M. R. Louis, "A Cultural Perspective on Organizations: The Need for and Consequences of Viewing Organizations as Culture-Bearing Milieux," Presented at the Annual Academy of Management Meetings, Detroit, August 1980.

**Title:** An Empirical Study of Information Gathering Behavior

**Investigator:** Norman R. Lyons, Associate Professor of Management Information Systems, Department of Administrative Sciences

**Sponsor:** NPS Foundation Research Program

**Objective:** To study the information gathering behavior of individuals using an economic computer game. The experimental environment will be manipulated so that a variety of information and resource conditions are tested. In addition, tests will be given to subjects to determine their propensity for risk taking behavior. The usage of information and the types of information requested by the subjects will be studied.

**Summary:** The Foundation granted funds for this study during Winter Quarter, 1980. During that time, the basic computer models for the game were set up on the IBM 360/67 system, a test instrument was developed, and preliminary runs were made on one of the classes in Management Information Systems. Some problems developed because the computer system at the school is in the last days of its existence, and it is not really capable of handling the demands placed on it by a game of this type. For the Information Game to work properly, it is necessary for the subject's jobs to get turn-around within about a minute. Normally, this is possible on the configuration at the school. However, toward the end of a quarter, this becomes a more difficult goal to attain. All of the computer programs are in place, but the completion of the experiments in this study may have to wait until the IBM 3033 system is fully operational early next year.

**Publications:** One article has been submitted for publication based on analysis of the risk-taking test. It is co-authored with Phillip Ein-Dor and is titled "Risk Taking Behavior: An Empirical Study" and it has been submitted to the American Journal of Psychology.

N. R. Lyons, "The Information Processing Game: An Experimental Tool for the Study of Information Processing Behavior," to be published in Simulation and Games.

Title: Computer System Performance Evaluation

Investigator: N. F. Schneidewind, Professor of Administrative and Computer Sciences

Sponsor: Aviation Supply Office, Planning and Data Systems Office

Objective: Improve the performance of computer systems management and operations at the Aviation Supply Office.

Summary: A visit has been made to ASO and data has been collected. Recommendations have been made concerning improvements in the methodology for computer system performance monitoring and evaluation.

Publications: A memorandum was written and provided to ASO on the subject indicated in the Summary



PROFESSOR NORMAN SCHNEIDEWIND ANALYZING  
COMPUTER PROGRAM COMPLEXITY.

Title: Database Management and Distributed Systems

Investigator: N. F. Schneidewind, Professor of Administrative Sciences and Computer Sciences

Sponsor: Naval Plant Representative Office

Objective: Compare various database management system technologies and advise Chief Engineer concerning utilization of this technology and of distributed systems at Lockheed Missile Systems Division. Also provide instruction to Naval Plant Representative personnel in database management and distributed systems.

Summary: Several meetings have been held with the sponsor for the purpose of learning about Lockheed's MDS database management systems. Instructional programs have been planned.

Theses  
Directed: Sudiyanto, "Distributed MIS", Master's Thesis, December 1979.

Chang Sup Yoon, "Relational Data Models", Master's Thesis, December 1979.

Title: Software Engineering (Software Maintainability)

Investigator: N. F. Schneidewind, Professor of Administrative Sciences and Computer Sciences

Sponsor: Trident, U.S. Navy, Communications and Control System Maintenance Agency

Objective: Evaluation of DOD software standards and specifications for application to software maintenance and development of improved software maintenance practices.

Summary: MIL-STD-1679, WS 8506 and SECNAVINST 3560.1 have been evaluated with respect to usefulness for software maintenance. Certain TRIDENT software maintenance practices have been reviewed and evaluated.

Publications: Three draft, unpublished reports have been prepared and sent to the sponsor for his review and comment during the course of this research. These reports will be integrated into a NPS final technical report.

Conference Presentations: To be one of the topics at a panel discussion to be chaired by the Principal Investigator at the 5th International Software Engineering Conference.

Thesis Directed: R. Pilcher, "Software Maintainability," Master's Thesis, March 1980.

**Title:** The Functions of Visual Mental Imagery

**Investigator:** Roger Weissinger-Baylon, Associate Professor of Management Information Systems, Department of Administrative Sciences

**Sponsor:** NPS Foundation Research Program

**Objective:** To discover the functions of visual mental imagery in problem-solving and decision-making. In addition to its contribution to the theory of cognitive processes, tracing complex processes with mental imagery, a technique with many applications in design and evaluation of computer information systems is under investigation.

**Summary:** Visual mental imagery protocols of mathematical problem solving contradict arguments by Nisbett and Wilson (1977) against the validity of protocol data in information processing psychology; my analysis is incompatible with Pylyshyn's (1973) characterization of mental images as epiphenomena, which I operationalize as stochastic independence between errors in reported mental images and problem-solving solutions. The rejection of stochastic independence (Fisher's exact test) suggests that mental imagery protocols provide valid traces of cognitive processes; moreover, images are not epiphenomena. As observed earlier by Arnheim (1969), Weissinger-Baylon (1978), Feigenbaum (1978) and Johnson-Laird (1979), mental images are important because they function as models of problems.

**Conference Presentations:**

"Visual Mental Imagery Is Not an Epiphenomen," Cognitive Science Society, 2nd annual meeting, Yale University, New Haven, Connecticut, June 1980 (abstract published in proceedings).

"The Functions of Visual Mental Imagery in Mathematical Problem Solving," Fourth American Conference on the Imaging Process, San Francisco, November 1980. (Proceedings are to be published in a book by Random House).

"Analyzing Executive Decision-Making Processes: the Methodological Contribution of Visual Mental Imagery," Philadelphia Pennsylvania, December 1980. (Referred contributed paper accepted for publication in proceedings).

Thesis  
Directed: Frederick Soetekouw, "A Response Evaluation Approach: An Aid for Computer Assisted Instruction Lesson Writing," Master's Thesis, September 1980.

Title: Sequential Testing for Selection

Investigator: R. A. Weitzman, Associate Professor of Administrative Sciences

Sponsor: NPS Foundation Research Program

Objective: To develop and test on Monte Carlo data a method of sequential aptitude testing for prediction of school success or failure with predesignated error probabilities (short-term) and to adapt this method for use with real data.

Summary: Like adaptive testing, sequential testing requires the presentation of one item at a time. The goal of adaptive testing is error variance, however, the goal of sequential testing is to control the probabilities of selection errors:  $\alpha$ , the probability of incorrect acceptance, and  $\beta$ , the probability of incorrect rejection. Varying these probabilities along with item difficulty and discriminability, this study found in 96 Monte Carlo studies of 1,000 examinees each that the number of items required tended to be larger for items of low than high discriminability and for low rather than high error probability. For  $\alpha = .05$  and  $\beta = .05$  with a 25% failure rate at school, for example, the mean test length was 10 for high-discriminability items and 37 for low items while the corresponding mean test lengths under the same conditions for  $\alpha = .15$  were 5 and 15. Predicted error rates were close to observed error rates particularly for the longer tests. These results suggest that in applications the strategy should be to fix  $\alpha$  low to control the quality of accepted applicants while fixing  $\beta$  to control mean test length. The next research step is to adapt the method to real data, where estimation of the probability of correctly responding to an item as a function of school performance appears to be the major problem. I expect to seek further Foundation support for this effort. The method, if it works on real data, can be useful for recruit selection and assignment.

Publication: R. A. Weitzman, "Sequential Testing for Selection", NPS Technical Report, NPS54-80-13, December 1980.

Conference Presentation: R. A. Weitzman, "Sequential Testing for Selection", Annual Meeting of the Psychometric Society, University of Iowa, May 1980.

Thesis Directed: R. S. Kayler, "Computerized Adaptive Testing: A Case Study," Master's Thesis, December 1980.

Title: Stepwise Pattern Analysis with Incomplete-tree and Bayesian Estimation

Investigator: R. A. Weitzman, Associate Professor of Administrative Sciences

Sponsor: Navy Personnel Research and Development Center

Objective: To develop methods of reliable prediction of criterion performance (e.g., officer retention) from qualitative data (e.g., commission source)

Summary: The project ended with the completion of the development work, including F and X stopping rules and illustration on actual Navy Class A school data.

Publications: R. A. Weitzman, "Stepwise Pattern Analysis with Incomplete-tree and Bayesian Estimation", Psychometrika, decision pending.  
R. A. Weitzman, "Stepwise Pattern Analysis", NPS Technical Report, NPS54-80-12, December 1980.

Thesis  
Directed: H. D. Mueller, "Estimation of Retention Rates of P-coded Naval Officers Conditioned on their Year of Graduation and Subspecialty Code," Master's Thesis, September 1980.

**Title:** Navy Health Care Systems: Professional/Paraprofessional Personnel Mix Study (HEALPERS)

**Investigators:** David Whipple, Associate Professor of Economics and Systems Analysis, Reuben Harris, Associate Professor of Organizational Behavior and Management, George Thomas and Kathy Kocher, Adjunct Professor's of Economics

**Sponsor:** Chief of Naval Operations

**Objective:** Develop a methodology for use at the facility (hospital) level in determining the appropriate mix of physician and non-physician providers (NPP) to staff specified clinics.

**Summary:** The present utilization and cost problems of NPP's in the civilian and military health care sectors were identified and analyzed. The tasks underlying the present peacetime staffing requirement of the Navy's health care system were identified and analyzed and a draft methodology developed. Structured field contact will be undertaken to indicate areas in need of modification. The draft methodology will then be refined and expanded to include a complete implementation strategy, tailored to the Navy's particular needs. The project is scheduled for completion in May 1981.

**Publications:** Bobby Gene Clark and David Whipple, "Non-Physician Providers: A Review of Their Utilization and Staffing," Working Paper #3, September 1979.

William C. Giauque and David Whipple, "An Analysis of Present Patterns of Non-Physician Provider (NPP) Usage in the Military Health Care System," Working Paper #4, October 1979.

David Whipple, "Non Physician Provider Project (HEALPERS)," Interim Report, January 1981.

## DEFENSE RESOURCES MANAGEMENT EDUCATION CENTER

The research program of the Defense Resources Management Education Center was initiated formally in 1979. Historically, DRMEC had directed execution. Consequently, research and publication effort came primarily from "found" time. 1980 marked the funding of three DRMEC research proposals with sponsorship from OSD, Director of Net Assessment; OSD, Manpower, Reserve Affairs and Logistics; and the NPS Foundation Research Program. The research program of DRMEC has developed into four segments: (1) relationships between defense budgets and defense capabilities in NATO Europe; (2) peacetime registration and the mobilization process; (3) multi-attribute techniques in decision making; and (4) the relationship of defense expenditures to growth in developing countries.

### DEFENSE BUDGETS AND DEFENSE CAPABILITIES, NATO EUROPE

Professor Sohlberg's research for the Director of Net Assessment, OSD, resulted in a methodology for assessing the degree of additivity possible when viewing NATO defense expenditures in the aggregate. This is a continuing area of research.

### PEACETIME REGISTRATION AND MOBILIZATION

Research by Professor Sohlberg in this area both for Rand and the Office of Manpower, Reserve Affairs and Logistics, OSD, resulted in a widely internationally disseminated NPS technical report. Professor J. Blandin and H. Nieuwboer are also pursuing projects in this area.

### MULTI-ATTRIBUTE TECHNIQUES

Professors Ivory and Mauer have concentrated their research efforts in this area. A NPS technical report is forthcoming.

### DEFENSE EXPENDITURES AND GROWTH

Professor Frederiksen in collaboration with Professor R. Looney of NSA have a continuing research activity in this area with both books and articles forthcoming.

**Title:** Quantification of Values for Decisions with Multiple Objectives

**Investigator:** Peter D. Ivory, Assistant Professor of Defense Resources Management Education Center

**Sponsor:** NPS Foundation Research Program

**Objective:** Summarize the available techniques on evaluation analysis for public-service managers.

**Summary:** Presently DOD managers rank projects in order of priority for funding. The ranking method requires decision makers to subjectively evaluate both benefits, which may involve multiple objectives, and costs for each project, then rank the projects in order of preference. The evidence on the human ability to subjectively evaluate complicated alternatives suggests strongly that humans perform the task poorly. After reviewing the literature on the available techniques to assist decision-makers in their value judgements, a simple methodology to resolve value assessment is developed. For simple tasks ranking is the best technique. However if the dimensions of the value problem exceed seven and or if cost is important, a normalized-direct method with the benefit/cost ratio rule is a superior method. Finally for complex value judgements the Simple Multiattribute Rating Technique with the benefit/cost ratio rule resolves most value problems characterized by having multiple objectives and allocates resources optimally. All three techniques can be performed by public-service managers without the assistance of an evaluation analyst.

**Publication:** A NPS technical report is in progress.

Title: Additivity of Allies

Investigator: Ragnhild Sohlberg, Assistant Professor of Defense Resources Management Education Center

Sponsor: Office of the Secretary of Defense

Objective: Improve OSD's understanding of the complex and diverse relationships between defense budgets and defense capabilities in NATO Europe, the ultimate objective of which is to improve NATO/WP military balance assessments.

Summary: The inadequacy of past methods for assessing military balances is recognized. However, past methods may also have been misleading. This study systematically addresses the problems confronted in comparing "non-comparables", identifies inputs and outputs to be included in alliance assessments, and describes selected features of the diverse "defense production functions" observed within NATO--features which should also be included in WP assessments.

The study led to many conclusions including:

Earlier methods using defense budgets as crude leading indicators of military balances ignored some components significant to the assessment.

The importance of distinguishing planned from realized capability changes as well as the problem of estimating realized real expenditures have been underestimated by past studies.

The importance of constantly re-evaluating capabilities acquired in the past in the light of current changes has not been recognized by methods using defense budgets; i.e., the interdependencies existing between expenditure components at a point in time and over time as well as intra-Alliance dependencies have not been recognized.

**Publications:** Unpublished, but planned reports in preparation include:

NPS Technical Report on theoretical problems and issues related to defense price indexes or deflators as well as examples of diverse NATO practices.

NPS Technical Report on the study as a whole.

Title: Peacetime Registration, Conscription and Mobilization Planning in European NATO

Investigator: Ragnhild Sohlberg, Assistant Professor of Defense Resources Management Education Center

Sponsor: Office of the Secretary of Defense

Objective: Improve the understanding of issues and practices relating to peacetime registration (national and military registration), universal or selective obligator military service, the use of reservists, and to augmentation of trained manpower in case of emergencies.

Summary: Continuing project. Working with MRAL to identify those issues of greatest use to them as well as identifying issues/problems/ideas which may prove useful. Issues given special treatment include national and military registration systems in Europe examples of force structures and the relationship to registration, conscription, etc., the role of women in various nations' defense structures.

In addition to Director, Mobilization and Deployment Planning, this project is of interest to a variety of agencies in Washington, D.C. (FEMA, National Security Council's Task Force on Mobilization, OSD, Director, Net Assessment).

Publications: R. Sohlberg, "Manpower Procurement Policies, Ground Force Structures and Registration Systems: Denmark, The Federal Republic of Germany, Norway, and the United Kingdom," D.R.M.E.C. Discussions Series Papers, 1-81, January 1981.

R. Sohlberg, "Defense Manpower Policy Analysis: NATO Ground Forces", P-6532 Rand Corporation, Santa Monica, June 1980.

## DEPARTMENT OF OPERATIONS RESEARCH

Operations Research is a multi-disciplinary field, a fact which is reflected by the variety of areas covered by the sponsored research of the faculty. The topics can be grouped into broad areas of basic research in the techniques of operations research and its applications to military problems. The techniques are mathematical programming and stochastic modeling. The applications areas are combat models, manpower and personnel, resource allocation, and command, control and communication.

### MATHEMATICAL PROGRAMMING

Mathematical programming represents the major optimization tool of operations research and the Naval Postgraduate School contributes to the profession through its basic research in the area.

Joint research by Professor Gordon Bradley of Computer Science and Professor Gerald Brown of Operations Research, sponsored by the Office of Naval Research, has led to the further development of extremely fast mathematical programming codes which exploit the special structure of certain optimization problems. Professor Brown has completed work on several material distribution applications.

### STOCHASTIC MODELING/STATISTICS

The other major approach in Operations Research is probabilistic model-building and statistical analysis. Many faculty contribute to this area.

Professor Donald Gaver, under ONR and Defense Communications Agency funding, has continued development of several models using a diffusion approximation technique for communications systems, computer systems, and for systems involving maintenance and repair. Professor James Esary has continued his studies in reliability. Professor Harold Larson and Professor Donald Barr have continued analysis of spectrometric data from oil analysis under sponsorship of the DOD.

Professor Peter Lewis derived properties for new stochastic point processes and time series models. In addition, new methods for simulating a broad class of stochastic point processes have been discovered. This work has been supported by ONR and the National Science Foundation. He also continues work in simulation analysis, particularly development of a revision to the LLRANDOM generator. Professor Patricia Jacobs continues to be funded by the National Science Foundation for work in related areas.

## COMBAT MODELS

The application of operations research to the development and employment of weapons reflects both the origin of the profession and the special role of the Naval Postgraduate School in the field.

Professors Sam Parry, Jim Hartman and Ed Kelleher have developed a computer simulation model for tank-anti-tank warfare for the Training and Doctrine Command. This model is now being used for studies supporting current decisions. Professor James Taylor has continued his fundamental studies of warfare via Lanchester-type differential equations including six papers published on work supported by ONR and the Army Research Office. On this topic a monograph has been completed and published by the Military Applications Section of the Operations Research Society. A text on Lanchester's Equations is planned for publication in 1981.

Professor Neagle Forrest has directed the Strategic Systems Project Office research program at the Naval Postgraduate School for several years. In addition, he has produced additional programmable calculator models for magnetic anomaly detection. In a similar area, Professor Rex Shudde has been developing routines for hand-held computers for use on board P-3 aircraft for the ASW Pacific Patrol Squadrons.

Professor Alan Washburn and Professor Bryce Tysver have done work for the Naval Torpedo Station in range studies. Professor Washburn also continued his studies of search and evaluation.

## MANPOWER AND PERSONNEL

The major cost of the U.S. military is for personnel. Planning and analysis of the personnel system is, therefore, of considerable interest. Professor Paul Milch is developing an interactive model of the Naval officer system for policy analysis and manpower/personnel planning. This is a cooperative research project between the Operations Research and Administrative Science Departments.

## COMMAND, CONTROL AND COMMUNICATIONS

Command, control and communications ( $C^3$ ) problems are a uniquely difficult problem for military organizations. Research in this area supports the new  $C^3$  curriculum at the Naval Postgraduate School. Professors Gary Poock and Russell Richards have participated in design of experiments for the ARPA-funded Advanced Architectural Test Bed (ACCAT) project. Professor Poock has had success in adapting available hardware to perform voice input of data to computers on the ARPANET.

Title: C-3 Laboratory Gaming Research

Investigators: A. F. Andrus, Associate Professor of Operations Research and J. W. Wozencraft, Professor of Electrical Engineering, and Chairman of C-3 Academic Program

Sponsor: Defense Advanced Research Project Agency

Objective: Provide computer software support to establish a basic in-house wargaming capability in the C-3 Laboratory.

Summary: Software was designed and written to provide an interactive color graphics movement dynamics display. The capabilities provided are:

Data Base Construction; position and movement information on all units.

Color display of units position and movement over time.

Publication: Technical report detailing work completed to date is in preparation.

Title: HP-67 Program Development and Support

Investigators: Alvin F. Andrus and Rex H. Shudde, Associate Professors of Operations Research

Sponsor: Office of Naval Research

Objective: Provide HP-67 program development and support to COMPATWINGSPAC for tactical development and evaluation.

Summary: Empirical and mathematical approaches were considered for providing accurate LORAN positioning within the tactical constraints of P-3 air crew capabilities and the memory constraints of the HP-67. Empirical curve fitting approaches were non-beneficial. This approach was considered by Professor Andrus. The mathematical approach was successful. This approach was considered by Professor Shudde.

Publications: Rex H. Shudde, "An Algorithm for Position Determination Using LORAN-C Triplets with a BASIC Program for the Commodore 2001 Micro-computer," NPS Technical Report, NPS55-80-009, March 1980.  
Rex H. Shudde, "Position Determination with LORAN-C Triplets and the Hewlett-Packard HP-67/97 Programmable Calculators," NPS Technical Report, NPS55-80-010, March 1980.  
The HP-67 program has been submitted to the Fleet Mission Program Library by COMPATWINGSPAC.

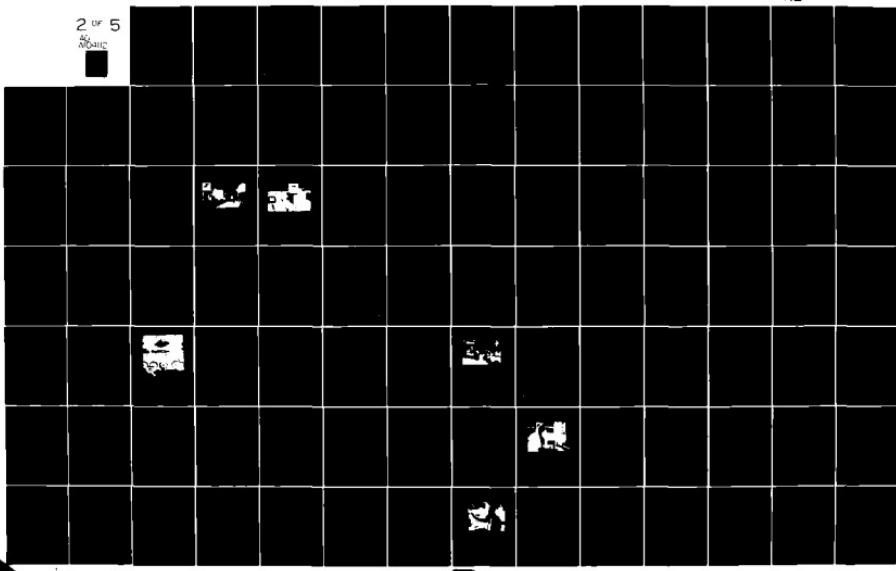
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**Title:** Research in Officer Manpower and Personnel Planning

**Investigators:** James K. Arima, Associate Professor of Operations Research and Behavioral Science, Paul R. Milch, Associate Professor of Operations Research and Statistics, Ronald A. Weitzman, Associate Professor of Management.

**Sponsor:** Principal Deputy Assistant Secretary of the Navy (Manpower and Reserve Affairs) and Deputy Chief of Naval Operations (Manpower Personnel Training)

**Objective:** Develop a dynamic interactive computer model of the Navy's officer corps that can be exercised for manpower/personnel planning and the evaluation of policy; conduct research and study efforts to support and complement the modeling.

**Summary:** The main thrust of the program has been the development of a prototype, interactive flow model of the Navy's URL officer communities. The model uses billets-at-sea as the requirement driving the system and "at sea" tour positions as the flow points through which individuals must pass as they age in the system. The user can input ships, billets per ship, sea tours, tour lengths, officer grades within tours, and a current inventory by years of service. The output shows overages or shortages in the billets by sea tours and grades, given the user's inputs. The model has been implemented on a commercial, time-sharing, computer system that can be accessed by telephone line for surface and subsurface communities and portions of the air community. A prototype model was developed to examine the relationship of sea to shore billets as an initial step in the process of including shore tours in the model. Other efforts have included applications of clustering algorithms for the clustering of subspecialty fields, statistical procedures for estimating the continuation rates of very small communities, and an examination of actual flow rates and paths for surface and maritime surveillance air communities. A survey to assess

The perceptions of officers regarding the billets they are receiving and the procedures for determining their assignments was conducted and the data are being analyzed.

Publication: R. C. Grinold, "A Study State Longitudinal Manpower Planning Model with Several Classes by Manpower," NPS Technical Report, NPS55-79-025, August 1979.

Theses  
Directed: George R. Parish, III, "The Relation of Naval Officer Promotion to Commission Source and Billet History," Master's Thesis, June 1979.

Jimmy W. Parker, "A Study of Surface Warfare Junior Officer Retention," Master's Thesis, September 1979.

Michael J. Panchura, Jr., "U.S. Naval Officer Perceptions of Billet Assignments and the Placement/Assignment Process," Master's Thesis, June 1979.

Victoria S. Mathews, and Sylvia S. Almendinger, "An Examination of Unrestricted Line Women Officers' Career Patterns and Related Issues," Master's Thesis, June 1979.

John F. Tepley, "An Interactive Computer Model to Analyze the Seatour Opportunities of the Submarine Officer Corps," Master's Thesis, March 1980.

E. L. Morris, "An Analysis of Officer Professor Development in the VP (Maritime Patrol) Aviation Community with Application of an Interactive Computer Model for Seatour Opportunity Determination," Master's Thesis, June 1980.

William H. Campbell, "Surface Warfare Officer Career Path Development and Its Relationship to Command Screening," Master's Thesis, June 1980.

**Title:** C<sup>3</sup> Technology Evaluation and Transfer

**Investigators:** Donald R. Barr, Professor of Operations Research and Gilbert T. Howard, Associate Professor of Operations Research

**Sponsor:** Naval Electronics Systems Command

**Objective:** To examine the operational potential of STAMMER and to familiarize students with this technology by involving them in the evaluation process.

**Summary:** An experiment has been designed to assess the practical utility of the STAMMER technology. This experiment will be conducted as soon as the decision rules in the STAMMER system can be enhanced and the data base can be expanded and made to correspond to a realistic scenario. Work on this is underway.

**Publications:** Work still in progress.

**Thesis  
Directed:** J. Ferranti, "An Assessment of STAMMER," Master's Thesis, in preparation (title tentative).

Title: NPS Support of ACCAT Experiments

Investigators: Donald R. Barr, Professor of Operations Research, and Gilbert T. Howard, Associate Professor of Operations Research

Sponsor: Naval Ocean Systems Center

Objective: To assist ACCAT in designing and executing a multinode experiment as a demonstration of the feasibility of conducting complex war game simulations at remote sites using the secure ARPANET for communications.

Summary: A demonstration was conducted in which San Diego (ACCAT), Hawaii (CINCPACFLT) and Monterey (NPS) served as various warfare coordinators in a WES driven war game.

**Title:** Large-Scale Optimization

**Investigators:** Gerald G. Brown, Associate Professor of Operations Research and Computer Science and Gordon H. Bradley, Chairman and Professor of Computer Science

**Sponsor:** Office of Naval Research

**Objective:** Continued development of theory and algorithms for solution of large-scale optimization models.

**Summary:** Large-scale models with Generalized Upper Bound and Network structure have been intensively studied: identification of such structure has been automated. Large linear, mixed integer, and nonlinear models can now be solved with the experimental optimization system developed over the period of this research. Decomposition and basis factorization have been incorporated with complete degeneracy resolution in a unique new algorithm for elastic programming. Applications at large scale have proven the efficiency of this approach for a broad range of problems. Computer-assisted analysis of problems prior to solution has materially contributed to several large-scale applications.

**Publications:**

- G. H. Bradley, G. G. Brown and G. W. Graves, "Structural Redundancy in Large-Scale Optimization Models," Redundancy in Mathematical Programming (Zoints and Telgen, eds.), Academic Press, to appear.
- G. G. Brown and D. S. Thomen, "Automatic Identification of Generalized Upper Bounds in Large-Scale Optimization Models," Management Science, to appear.
- G. H. Bradley, G. G. Brown and P. I. Galatas, "ATHENA: A System to Interactively Analyze Large-Scale Optimization Models," NPS Technical Report, NPS52-80-005, April 1980.
- G. H. Bradley, G. G. Brown and P. I. Galatas, "ATHENA: Users Manual for Interactive Analysis of Large-Scale Optimization Models," NPS Technical Report, NPS52-80-006, April 1980.

G. G. Brown, A. M. Geoffrion and G. H. Bradley, "Production and Sales Planning with Limited Shared Tooling at the Key Operation," Management Science, to appear.

G. G. Brown and G. W. Graves, "Real-Time Dispatch of Petroleum Tank Trucks," Management Science, to appear.

G. G. Brown and A. R. Washburn, "Khachian's Algorithm: A Tutorial," NPS Technical Report, NPS55-80-008, February 1980.

G. G. Brown and W. R. Wright, "Identification of Embedded Network Rows in Large-Scale Optimization Models," Computer-Assisted Analysis and Model Simplification, Academic Press, to appear.

G. H. Bradley and G. G. Brown, "Computational Analysis of the BNL Regional Demand Pulp and Paper industrial Process Model," Brookhaven National Laboratories, June 23, 1980.

G. G. Brown and W. G. Wright, "Identification of Embedded Special Structure in Large-Scale Optimization Models," IIASA Large-Scale Optimization, Academic Press, to appear.

Thesis  
Directed: "Automatic Identification of Network Rows in Large-Scale Optimization Models," W. G. Wright, Master's Thesis, September 1980.

**Title:** FBM Vulnerability and Effectiveness Studies

**Investigators:** R. N. Forrest, Professor of Operations Research, and Alan R. Washburn, Associate Professor of Operations Research

**Sponsor:** Strategic Systems Project Office

**Objective:** To develop models for evaluating FBM vulnerabilities and effectiveness.

**Summary:** A model for assessing the detectability of a phenomenon modeled by a dipole distribution and a model to illuminate localization and tracking problems have been developed.

Title: An Investigation of Localization and Tracking Procedures

Investigator: R. N. Forrest, Professor of Operations Research

Sponsor: NPS Foundation Research Program

Objective: To develop a passive acoustic sensor target motion analysis (TMA) procedure that uses data that is not used in existing procedures.

Summary: The research project is exploratory. A computer model has been developed that simulates an encounter between an acoustic source (target) and an acoustic sensor. As a reference, an existing TMA procedure has been investigated using the simulation. The procedure is being modified by the introduction of speed and range constraint distributions. The modification provides target course and speed distributions. The problem of characterizing the distributions in a practical way is being addressed. The ultimate goal of the research is the development of a procedure that will reduce the time required to obtain adequate weapon localization information.

Publication: A technical report describing the simulation and base line TMA procedure is being prepared.

**Title:** Modeling the Influence of Information on  
the Progress of Conflict or Combat by  
Mathematical and Computational Methods

**Investigator:** Donald P. Gaver, Professor of Operations  
Research and Statistics

**Sponsor:** NPS Foundation Research Program

**Objective:** Development of models to represent the  
effect of information flow and Command,  
Control, Communication ( $C^3$ ) activities  
on combat.

**Summary:** The research activity was devoted to  
developing models and approaches to repre-  
senting  $C^3$  system effects on Lanchester-  
type attrition models. In particular,  
coordination payoff was modeled. Communi-  
cation system models were also investi-  
gated, wherein interference and jamming  
featured.

**Publication:** Donald P. Gaver, "Models that Reflect the  
Value of Information in a Command and  
Control Context," NPS Technical Report,  
NPS55-80-027, October 1980.

**Conference  
Presentation:** D. P. Gaver, J. P. Lehoczky and R. Harvey,  
"Communication Queues Under Crisis Condi-  
tions," TIMS/ORSA Joint National Meeting,  
Washington, DC, May 1980.

Title: Research in Communication, Command, Control  
and Intelligence

Investigators: Donald P. Gaver, Professor of Operations  
Research and Statistics, J. Wozencraft,  
Chairman, Command, Control, and Communi-  
cations Group, F. Russell Richards, Associate  
Professor of Operations Research, and P.  
Moose, Associate Professor of Electrical  
Engineering

Sponsor: Defense Advance Research Project Agency

Objective: Formulation of new Lanchester-type combat  
model equations involving information-  
related effects such as Counter-C<sup>3</sup>.

Summary: The activity on this project was formally  
begun only during period 19 October 1980-  
December 1980. Progress has been made.

Title: Quantity Verses Quality in Naval Ship Procurement Decisions

Investigator: CAPT Wayne Hughes, Jr., USN, Chair Professor of Applied Systems Analysis

Sponsor: Office of Chief of Naval Operations

Objective: To develop the analytical foundation and structure common to the study of quantity verses quality, or high-low mix, decisions.

Summary: A statement of the problem has been formulated along with the elements involved in quantity-quality tradeoffs. Three tentative models to illustrate the methodology have been derived. Current work consists of discussions with analysts familiar with the problem and collecting data from past studies.

Title: Probabilistic Models for Complex Systems

Investigator: Patricia A. Jacobs, Associate Professor of Operations Research

Sponsor: National Science Foundation, Engineering Division, Systems Analysis and Operations Research Program

Objective: The purpose of the research is to study probabilistic models for complex systems such as stress on structures caused by extreme load combinations. This grant continues research previously supported by NSF grants numbers ENG-77-09020 and ENG-79-01438.

Summary: The research program has continued in several areas. In the area of non Gaussian time series a simulation study of estimation procedures for the parameters of a stationary discrete time series model DAR (1) was done. The results indicate that an ad-hoc estimator for correlation that is based on the structure of the model is nearly as good as the more computationally complex maximum likelihood estimator for small (size 20) to moderate (size 200) sample sizes. Both types of estimators are better than the usual ratio estimator for correlation. A discrete time series of maximum daily oxidant levels in Livermore, California, was analyzed and a strong apparently linear relationship between oxidant level and temperature was found. Research continued on models for combinations of random loads and preliminary simulation studies were done to explore the robustness of asymptotic results. Research was begun on the usefulness of diffusion models in problems of control in manpower systems.

Publications: D. P. Gaver and P. A. Jacobs, "On Combinations of Random Loads," NPS Technical Report, No. NPS55-80-006, January 1980.  
P. A. Jacobs, "Preliminary Analysis of Maximum Daily Oxidant Data," NPS Technical Report, No. NPS55-80-025, August 1980

**Conference  
Presentations:**

P. A. Jacobs, "Queues with Correlated Inter-arrival and Service Sequences," Joint National Meeting TIMS/ORSA, Washington, DC, May 1980.

P. A. Jacobs, "Discrete Time Series Arising in the Analysis of Daily Maximum Oxidant Levels," Joint National Meeting TIMS/ORSA, Washington, DC, May 1980.

**Title:** Enhancements to the LLRANDOM II Random Number Generator Package

**Investigator:** Peter A. W. Lewis, Professor of Operations Research

**Sponsor:** NPS Foundation Research Program

**Objective:** To complete development of the Assembly Language Program LLRANDOM II for rapid generation of arrays of uniform and non-uniform random numbers.

**Summary:** Newly developed methods for generating Gamma distributed random variables have been implemented in the GAMMA portion of LLRANDOM II, completing the development of the package. The philosophy behind the package was to provide arrays of uniform and non-uniform random numbers to users which have: (i) known and documented statistical properties; (ii) are efficiently computed; and (iii) are reliably computed. Unlike LLRANDOM I, all the subprograms in LLRANDOM II are independent modules which follow all IBM standard linkage conventions and, therefore, can be called from all IBM high level languages (FORTRAN, PL (1, etc.)) which use the standard linkage conventions. A feature of LLRANDOM II is that two multipliers are provided for the primemodulus congruential random number generator and the package is written in such a way that up to ten multipliers can be included.

**Publications:** Two reports entitled "The New LLRANDOM II Package Random Number Generator Package" and "The New LLRANDOM II Package - Users Guide" are being completed. The program will be available to the users of LLRANDOM I. These users include Navy and other government facilities, universities and private businesses.

Title: Stochastic Analysis

Investigators: Peter A. W. Lewis, Professor of Operations Research and Statistics, Donald P. Gaver, Professor of Operations Research and Statistics

Sponsor: Office of Naval Research

Objective: To develop models for the analysis of stochastic point processes and time series, develop new statistical methodology for use in simulations, and to pursue probability modelling, numerical methodology and data analysis techniques for communications networks and other stochastic systems.

Summary: A very general 2-parameter first-order auto-regressive exponential process (GNEAR (1)) has been derived. This process will give the full range of correlations obtainable with bivariate exponential variates and a wide range of sample path behavior. It is extendable to a complete mixed autoregressive moving average correlation structure to give a GNEAR (p,q) process. Multivariate structures open estimation problems and applications in stochastic systems are being investigated.

Processes with mixed exponential and Gamma marginals have been derived but this work is not as complete as that for the exponential case.

The thinning method for simulating non-homogeneous Poisson processes has been extended to renewal process. It gives an entirely new way of generating random variables based on the hazard function instead of the probability density function.

A statistical and graphical method (regression adjusted graphics and estimation) has been developed and applied to the analysis of regenerative simulations. The method allows a sequential analysis of the size of the simulation required to obtain a given precision in the estimate. The methodology is being applied to other

simulation output analysis problems. A solution has been obtained to the problem of obtaining quantile estimates from (simulated) sequences of dependent data. The method is robust with respect to initial transients in the sequence. It uses max-min and next-to-max-next-to-min transforms in a folded two-way table of the data. The output is both point and confidence interval estimates. The data compaction achieved in the procedure is very large.

Point process methodology is being applied to that analysis of sleep-wake behavior in mice (*mus musculus*). Initial data analysis has indicated that there is no evidence for ultradian rhythms in mice (*mus musculus*). Further analysis of circadian rhythms using complete intensity functions is underway.

Work continued on the probabilistic study of delays at communications channels that cooperatively service data and voice messages, voice having preemptive priority.

A report was completed on the influence of information on combat outcome. This work will be of use in evaluating the contribution of Command and Control. A second report is in progress.

Models were derived for the performance of service systems under stress, such as might be encountered in a Command-Control environment. A presentation was made at the Annual ORSA meeting, and another at Bell Telephone Labs. A paper will be prepared.

Lectures on applied statistics and data analysis were prepared for, and presented at, a Summer School in Remote Sensing held at the University of Dundee, Scotland. These lectures will appear in a book to be published by Ellis Horwood, England.

Work continues on convenient methods for sampling from variations of standard distributions ("distributional sculpturing") and for approximating distributions and

their inverses. Some of this is on-going with K. Kafeder of the U.S. Bureau of Standards.

- Publications:**
- P. A. W. Lewis and A. J. Lawrance, "A Mixed Exponential Time Series Model, NMEAR (p,q)," submitted to Management Science.
- P. A. W. Lewis and A. J. Lawrance, "A New Autoregressive Time Series Model in Exponential Variables, NEAR (1)," accepted for publication in J. Applied Probability.
- P. A. W. Lewis and A. J. Lawrance, "The Exponential Autoregressive-Moving Average Sequence EARMA (p,q)," appeared in J. Roy. Stat. Soc. B, Vol. 42, No. 2, 1980.
- D. P. Gaver and P. A. W. Lewis, "First Order Autoregressive Gamma Sequences," appeared in Ad. Appl. Prob., Vol. 12, No. 2, 1980.
- P. A. W. Lewis and P. Heidelberger, "Regression-adjusted Estimates for Regenerative Simulations, with Graphics," will appear in Comm. of the ACM in March.
- P. A. W. Lewis and A. J. Lawrance, "Generation of Some First-Order Autoregressive Markovian Sequences of Positive Random Variables with Given Marginal Distributions," NPS Technical Report, NPS55Lw-81-003, and will appear in the Proceedings of the AP/CMS conference.
- P. A. W. Lewis, "Chapter G of the IMSL Library-Generation and Testing of Random Divariate: Simulation," appeared in the Proceedings of the 1980 Winter Simulation Conference.
- P. A. W. Lewis, G. Richardson and W. Dement, "Serial Correlation in Sleep and Wakefulness States in the Mouse: Dependence on Circadian Phase," appeared as a Stanford Technical Report and has been submitted to Science.

D. P. Gaver and P. A. Jacobs, "On Combinations of Random Loads," to appear in SIAM J. for Applied Mathematics.

D. P. Gaver and P. A. Jacobs, "Storage Problems When Demand is 'All or Nothing,'" to appear in Naval Research Logistics Quarterly.

D. P. Gaver and J. P. Lehoczky, "Channels that Cooperatively Service a Data Stream and Voice Messages," submitted to IEEE Trans. on Communications.

J. P. Lehoczky and D. P. Gaver, "Diffusion Approximations for the Cooperative Service of Voice and Data Messages," to appear in the Journal of Applied Probability.

**Title:** NPS Support for the R&D Function of the Development Center

**Investigator:** Glenn F. Lindsay, Associate Professor of Operations Research

**Sponsor:** United States Marine Corps Development Center

**Objective:** Continuation of a program of general technical support for the Development Center, together with specific activities aimed at increasing the use of Operations Research and modern managerial techniques at the Center.

**Summary:** In addition to a variety of advisory tasks completed primarily by telephone, NPS faculty worked on site with newly arrived development project officers. This included a series of workshops emphasizing concepts of scientific investigation, technical terminology, investigative practices, and R&D management, with the objective of accelerating the development project officer's progress over his on-the-job learning curve. This was a renewal of the project with tasks identical to those of FY-79 and FY-78.

**Title:** Development of a Local Material Distribution Plan

**Investigator:** Alan W. McMasters, Associate Professor of Operations Research and Administrative Sciences

**Sponsor:** Naval Supply Center, Oakland

**Objective:** This is a continuing research effort to develop a general material distribution plan for local area support by a large wholesale activity which can then be applied to the Naval Supply Centers at Oakland, San Diego, and Norfolk.

**Summary:** The Navy is in the process of implementing a recommendation of the DOD Material Distribution System (DODMDS) Study that the management and administration of wholesale supply operation of the Naval Air Stations be merged with the Naval Supply Centers (NSC) at Oakland, San Diego and Norfolk. Further, this action results in a direct support relationship between the NSC's and the local Naval Air Rework Facilities (NARF). This consolidation provides opportunity to develop a new local material distribution plan which will greatly improve supply support to all local customers of a NSC.

The procedure consists of the following four phases:

Material Characteristics Sensitivity Analysis

Material Flow Analysis

Stock Positioning/Material Distribution Algorithms

Production Support Inventories

During the past year the following progress was made:

The analysis of local customer business to NSC Oakland has been completed for the base year FY'78. Information on the demands from each customer has been analyzed and reported. In addition, the modes, schedules, and costs, of local delivery activities have been documented. Similar information has been obtained for the demands from the NARF to the Naval Air Station Supply Department at Alameda prior to the consolidation.

A model for determining the range and depth of items to be placed in a Ready Supply Store (RSS) by NSC to provide special supply support to the NARF has been developed. It incorporates the quarterly work schedule into the demand distribution. Estimation of parameter values is underway.

The location of special inventories such as the RSS is dependent upon the delivery strategy, costs of delivery and delay, the demand distribution, and response-time standards. Such a model has been developed to study when an item should be positioned at the NSC and when it should be positioned at the NARF. Documentation of local customer business at NSC San Diego will be attempted. A truck-scheduling algorithm will also be recommended as an integral part of the improvements in the local delivery system.

**Publication:** Alan W. McMasters, "A Repair Parts Inventory Model for a Naval Air Rework Facility," Naval Postgraduate School Technical Report, NPS54-80-04, May 1980.

**Conference Presentation:** Alan W. McMasters, "Development of a Local Area Material Distribution Plan for Large Wholesale Supply Activities," presentation No. WA04.3. TIMS/OSRA Joint Nat'l Meeting, Washington, DC, May 4-7 1980.

- Theses  
Directed:
- Eylon Baruch, "A Proposed Material Requirements Planning System for NARF Alameda." Master's Thesis, March 1980.
- Bryan Hrabosky, Wayne A. Owens and Ronald G. Popp, "Pre-Consolidation Supply Support for NARF Alameda and of NSC Oakland's Local Customers," Master's Thesis, September 1980.
- R. T. Macon, "Naval Air Station Alameda's Material Distribution System," Master's Thesis, December 1979.
- R. G. Ostrom, "A Discussion of the Wholesale Support Provided to the Naval Air Rework Facility by the Naval Air Station, North Island," Master's Thesis, December 1979.
- J. E. Vogelsang, "Pre-Expended Bin Material Management at Naval Air Rework Facilities," Master's Thesis, June 1980
- Richard J. Wieczorek, and Lon E. Eastland, "An Analysis of Material and Distribution from Naval Supply Center, Oakland, to Local Customers," Master's Thesis, December 1979.

**Title:** Stock Migration from NAVELEX to SPCC

**Investigator:** Alan W. McMasters, Associate Professor of Operations Research and Administrative Sciences

**Sponsor:** Naval Electronic Systems Command

**Objective:** This is a continuing research effort addressing the question of when inventory management of an item should be transferred from NAVELEX to SPCC.

**Summary:** This year's efforts have been directed towards trying to develop failure-rate curves for 2Z cog items. Such curves have been successfully obtained for those items developed since 1970. These curves show that new items tend to exhibit high failure rates during the first two years but, by the end of the third year, they display low constant rates. In contrast, items which are updated versions of earlier developed ones show only low constant rates. The difference between the new and the updated appears to be caused by the user's lack of familiarity with the new rather than by design problems.

Attempts are currently being made to develop failure rate curves for those items developed prior to 1971. Unfortunately, random demand data is only available from 1971 to the present and determination of installed population requires working backwards from existing values in the Weapon System file. However, as soon as these curves can be developed, discussions will begin with the inventory managers and engineers in an attempt to confirm if the users are actually the cause of high failure rates.

Title: Application of Color Coding in Tactical Displays in the S-3A

Investigator: D. E. Neil, Associate Professor of Operations Research

Sponsor: Naval Air Development Center

Objective: Examine the benefits and/or detriments that might be associated with the use of color as coding modality in tactical display systems aboard the S-3A.

Summary: Effort involved an examination of the literature on the subject of color coding in CRT design. Specific intent was to review available literature on the subject as it might apply to tactical display design aboard the S-3A aircraft. Based on the literature and knowledge of missions and operational environments of the system it was concluded that the addition of color as a coding modality would not enhance performance sufficiently to be cost effective.

Publication: D. E. Neil, "Application of Color Coding in Tactical Displays in the S-3A aircraft," NPS Technical Report, NPS55-80-013.

Thesis  
Directed: Heening Hoops, "The Advantages of the Color Code Modality Versus Alphanumeric and Symbol Code," Master's Thesis, March 1980.

**Title:** Study of the Ability of Voice Input Systems to Function in a Bilingual Environment

**Investigator:** D. E. Neil, Associate Professor of Operations Research

**Sponsor:** Naval Electronics Systems Command

**Objective:** Investigate the feasibility of using voice input in bilingual environments.

**Summary:** A laboratory experiment was conducted for the purpose of determining the ability of commercially available voice input equipment to function in a bilingual situation. Bilingual subjects (German/English) were selected to perform in a command and control type environment. Equipment was programmed in English alone, German alone and combined English/German. Results indicated performance was significantly degraded under the combined program.

**Publication:** D. E. Neil, "An Investigation of the Ability of Voice Recognition Equipment to Function in a Bilingual Environment," NPS Technical Report (in preparation).

Title: Development of the Simulation of Tactical Alternative Responses (STAR) Model

Investigators: Samuel H. Parry, Associate Professor of Operations Research, James K. Hartman, Associate Professor of Operations Research and Arthur L. Schoenstadt, Associate Professor of Mathematics

Sponsor: None

Objective: Continue the development and validation of the basic STAR Brigade model to include all elements of the Combined Arms Task Force. Develop a limited visibility model capable of representing combat in a smoke/dust environment as well as under the full spectrum of illumination and weather conditions. Continue development of the COM/EW model to represent appropriate command and tactical nets, as well as selected noncommunication emitters. Initiate research to determine the feasibility of representing nuclear and chemical warfare in STAR. Explore methodology to represent variable aggregation levels in STAR. Continue development of the Division and Corps hierarchy of STAR to represent the Command, Control, Communications and Computer functions as they interface with the STAR Brigade Model.

Summary: STAR is a high resolution, event structured, stochastic two-sided simulation of the combined arms air/land conflict. The model may be run using either digitized terrain or a continuous, functional terrain representation developed at NPS. All units are resolved to the individual vehicle or soldier level. Conflicts are modelled between a Blue Brigade/Red Division echelonment, or any subset of these organizations. The model is capable of playing a wide range of resource allocation, fire and maneuver tactics easily modified by the user. The research effort in support of the objectives continued in several areas. Significant progress was made in the development of the STAR Brigade model, especially in the area of

limited visibility representation and the COM/EW modules. The nuclear and chemical warfare module was deferred until FY 1981. The aggregation research in support of the Division/Corp model was initiated and a background investigation completed. The model was used to support three major U.S. Army Studies during FY 1980, and several studies are anticipated for FY 1981.

- Publications:**
- S. H. Parry and E. P. Kelleher, "Tactical Parameters and Input Requirements for the Ground Component of the STAR Combat Model," NPS Technical Report, NPS55-79-023, October 1979.
- S. H. Parry and E. P. Kelleher, "Range Band Study Using the Simulation of Tactical Alternative Responses (STAR) Model," May 1980.
- Theses  
Directed:**
- J. H. Lane, "A Computerized Model of Remotely Piloted Vehicle Flight for Intelligence Gathering," Master's Thesis, March 1980.
- J. F. Affeldt, "A Parametric Analysis of the Techniques Used for the Recovery and Evacuation of Battle Damaged Tracked Vehicles," Master's Thesis, June 1980.
- R. F. Dees, "Modeling Interdiction of the VTOROY Eschelon," Master's Thesis, June 1980.
- H. J. Carpenter and E. E. Thurman, "Parametric Simulation of Infantry Tactics and Equipment (Dismounted STAR)," Master's Thesis, June 1980.
- A. G. Loerch, "Simulation of the Direct Support Maintenance System in the Brigade Area," Master's Thesis, September 1980.
- P. Olson, "Communications Model for Simulation of Tactical Alternative Responses (STAR)," Master's Thesis, September 1980.

J. R. Prouty, "A Methodology for Describing  
the Performance of Air Defense Systems  
Using Field Experiment Data," Master's  
Thesis, September 1980.

Title: Voice Input for Command and Control Systems

Investigator: Gary K. Poock, Professor of Operations Research

Sponsor: Naval Electronics Systems Command

Objective: To investigate the feasibility of using voice recognition equipment to recognize spoken commands and then take actions automatically instead of having the human being do lots of manual controlling.

Summary: Several experiments were carried out with military officers using voice recognition equipment. The officers were able to effectively run large scale computer networks faster and with fewer errors by using voice input than they were able to do by using manual typing input. Other experiments with voice recognition are in progress.

Publications: G. K. Poock and J. W. Armstrong, "Effect of Operator's Task Load on Performance of a Voice Recognition System," Perceptual and Motor Skills, Vol. 51, 1980.  
G. K. Poock, "Experiments with Voice Input for Command and Control: Using Voice Input to Operate a Distributed Computer Network," NPS Technical Report, NPS55-88-016, April 1980.

Conference Presentations: G. K. Poock, "Voice Input For Military Decision Aids," presented at 44th MORS Meeting, Vandenburg Air Force Base, California, Fall 1979.  
G. K. Poock, "Voice Input for Command and Control Computer Networks," Presented at Conference on Voice Interactive Systems: Applications and Payoffs, Dallas, Texas, May 1980.

Thesis Directed: John Armstrong, "Effect of Motor Loading Stress on Performance of a Voice Recognition System," Master's Thesis, September 1980.



PROFESSOR GARY POOCK USING VOICE  
RECOGNITION EQUIPMENT FOR DATA INPUT  
TO COMPUTERS



CAPT GREG JAY, USAF, ACTING AS PHOTO  
INTERPRETER USING VOICE RECOGNITION  
EQUIPMENT FOR DATA ENTRY.

Title: Review of SIDAC-C

Investigator: R. R. Read and J. D. Esary, Professors  
of Operations Research

Sponsor: Defense Communications Agency

Objective: Evaluate statistical techniques and methods  
used to track uncertainty through SIDAC  
(Single Integrated Damage Assessment  
Capability). The resulting, model called  
SIDAC-C, is the confidence interval version.

Summary: The computer programs used in SIDAC are  
extremely complicated and require excessive  
running time. Accordingly SIDAC-C utilizes  
some approximations in order to produce  
"confidence intervals" for the output  
quantities of SIDAC. Simulation of SIDAC  
produces some isolated support for the use  
of these approximations. We applied the  
same techniques to related but much simpler  
models and showed the existence of impor-  
tant and sizable regions where the approx-  
imations are quite poor. Also, selected  
equations and assumptions of SIDAC-C have  
been critiqued. Some alternative approaches  
have been suggested for follow-on work.

Publication: Report has been delivered to the Sponsor.

**Title:** Study of Contour Construction Techniques Applicable to MX Valley Design Parameters

**Investigator:** R. R. Read, Professor of Operations Research

**Sponsor:** Defense Nuclear Agency

**Objective:** To provide suitable methodology for the construction of subsurface contour maps of pertinent soil characteristics in the MX valley sites based on the data obtained from the drilling holes specified by the sampling plan.

**Summary:** An extensive literature search has been made of the newly developed (last decade) interpolation methods in two and higher dimensions. These have been screened for the MX vallies. Construction programs have been located for several of these. Also a contour construction method using interpolation techniques for input has been located.

Title: Research in Communications, Command, Control and Intelligence

Investigators: F. Russell Richards, Associate Professor of Operations Research, J. Wozencraft, Chairman Command, Control, and Communications Group, D. P. Gaver, Professor of Operations Research, and P. Moose, Associate Professor of Electrical Engineering

Sponsor: Defense Advanced Research Projects Agency

Objective: To develop basic conceptual frameworks for C<sup>3</sup>I; to develop and compare weaknesses and strengths of simulations, war games, and exercises as C<sup>3</sup>I research tools; and to develop and test interdisciplinary measures for evaluating the effectiveness of proposed improvements in C<sup>3</sup>I.

Summary: A review was made of extant war gaming models. Participated as a player in the Naval War College SEASON-80 wargame; the Warfare Environment Simulator (WES); Integrated Corps Game (ICOR); Seminar and Hybrid Seminar Games (KETRON). Evaluation of the utility of existing war gaming models for C<sup>3</sup> research is in progress. The development of the architecture for the NPS C<sup>3</sup>I research evaluation war game is underway.

**Title:** Lanchester-Type Models of Warfare (Monograph)

**Investigator:** James G. Taylor, Professor of Operations Research

**Sponsors:** U. S. Army Research Office and U. S. Air Force Headquarters

**Objective:** To complete the writing of and to edit a monograph about Lanchester-type (i.e. differential-equation) models of force-on-force attrition in combat operations. The monograph should integrate and synthesize modelling ideas and results that have heretofore been either widely scattered in the literature or otherwise inaccessible to military-operations-research analysts. It should stress methodological aspects but should also give consideration to current operational air-ground conventional-combat models and should try to relate these two important aspects to each other.

**Summary:** A first draft of the monograph Lanchester-Type Models of Warfare (approximately 1450 typewritten pages) was completed and submitted for publication as a research monograph in the "Publications in Operations Research Series" of the Operations Research Society of America. This monograph is a comprehensive treatise on Lanchester-type models of warfare. Its goal is to provide both an introduction to and current-state-of-the-art overview of Lanchester-type models of warfare, as well as a comprehensive and unified in-depth treatment of them. Both deterministic as well as stochastic models are considered. Methodological aspects have been stressed. For the first time a comprehensive and unified treatment of the conceptual bases of Lanchester-type combat models and their known mathematical properties now exists. The author has attempted to treat all relevant aspects, e.g. modelling of attrition-rate coefficients, stochastic Lanchester-type models, modelling of tactical engagements (including references to current operational combat models).

Publication: J. G. Taylor, "Lanchester-Type Models of Warfare, American Elsevier/North Holland," submitted for publication.

Thesis  
Directed: K. D. Klemm, "A Further Comparison of Deterministic and Stochastic Lanchester-Type Combat Models," Master's Thesis, September 1980.

Title: Analysis of the Memoryless Tracker

Investigator: Alan R. Washburn, Associate Professor of Operations Research

Sponsor: Department of the Navy, Strategic Systems Project Office

Objective: As acoustic and electromagnetic sensors achieve longer and longer detection ranges, the problem of tracking a target in the presence of false alarms becomes increasingly important. This research investigates an abstract version of the problem where intermittent contact is obtained on a randomly moving target.

Summary: The objective is to maintain track as long as possible, where track is by definition maintained as long as no false contact is accepted or true contact rejected. The acceptance policy that maximizes mean tracking time is derived.

Publication: Alan R. Washburn, "Analysis of the Memoryless Tracker," NPS Technical Report, NPS55-80-014, April 1980.

Title: Expanding Area Search Experiments

Investigator: Alan R. Washburn, Associate Professor of Operations Research

Sponsor: Department of the Navy, Strategic Systems Project Office

Objective: The problem of searching for an evasive target when the searcher arrives late after a localization is an old one, and there is a theory based on the idea of random search that predicts probability of detection. This research tests whether the theory's predictions are accurate for "real" searches.

Summary: A "real" search is defined to be whatever an officer-student does in manipulating his joystick in an electronic version of the game when he understands that a different officer-target joystick in an attempt to avoid detection. The theory is compared with the results of repeated trials, and turns out to be reasonably accurate.

Publication: Alan R. Washburn, "Expanding Area Search Experiments," NPS Technical Report, NPS55-80-017, May 1980.

Title: On the Tradeoff Between Drift and Variance

Investigator: Alan R. Washburn, Associate Professor of Operations Research

Sponsor: None

Objective: A target with top speed  $V$  who has to go from A to B in the face of enemy fire has a problem: If his speed of advance (SOA) is too close to  $V$ , enemy fire will be very accurate because his track will be nearly a straight line. If his SOA is too slow, enemy fire will be inaccurate, but so prolonged that a hit is still likely. The objective of this research is to study how the target ought to move.

Summary: Various types of motion and measures of effectiveness are defined and analyzed. One implication of the results is that the best SOA is about  $V/\sqrt{3}$ .

Publication: Alan R. Washburn, "On the Tradeoff Between Drift and Variance," NPS Technical Report, NPS55-80-002, January 1980.

Title: Overlapping Pulse Trains

Investigator: Alan R. Washburn, Associate Professor of Operations Research

Sponsor: None

Objective: There are a variety of problems that reduce essentially to the question, "When will several pulse trains with specified periods and pulse widths all be simultaneously 'on' for the first time?" Signal intercept problems, for example, are sometimes of this type. The problem is hard to answer in general because of the possibility of synchronism: if the periods are all the same overlap may never occur. The objective is to describe the intercept time in the asynchronous cases.

Summary: A simple formula for the mean intercept time is derived and tested by computer simulation. The formula is a very rough but nonetheless useful guide to what actually happens.

Publication: Alan R. Washburn, "Overlapping Pulse Trains," IEEE Transactions on Aerospace and Electronics Systems, Decision Pending.

Title: Search for a Moving Target: the FAB Algorithm

Investigator: Alan R. Washburn, Associate Professor of Operations Research

Sponsor: None

Objective: It has recently become possible to optimize distribution of effort searches for a target that moves even as the search progresses. The best way to search depends on what measure of effectiveness is used. In previous work, the measure of effectiveness used has almost always been probability of detection after a fixed time. The objective here is to find out how to optimize search using other measures of effectiveness such as mean time to detection.

Summary: It is discovered that a modification of the same algorithm used for the probability of detection problem (the FAB algorithm) can also be used to solve a more general class of problems.

Publication: Alan R. Washburn, "Search for a Moving Target: the FAB Algorithm," Operations Research, decision pending.

## DEPARTMENT OF NATIONAL SECURITY AFFAIRS

The research program of the Department of National Security Affairs has continued along several main lines: (1) regional politico military analysis with a focus on particular geographical areas, (2) analysis of Soviet military activities, (3) military deception and perception management, (4) operational test and evaluation and (5) maritime theater nuclear warfare.

### REGIONAL POLITICO MILITARY ANALYSIS

These analyses have continued to focus on those areas of the world of vital interest to the United States, including Africa, the Middle East and Europe. Research on the Far East and Sino-Soviet relationships is in process but not included in this report.

The African research included assessments of regional cooperation in Southern Africa, the military involvement of communist countries and the development of computerized indications and warnings of domestic and international upheavals in Africa.

Middle East studies assess the impact of Islamic culture on the acceptance of Western military techniques, the Soviet invasion of Afghanistan in December 1979 and the economic impact of arms transfers on pre-revolutionary Iran.

Research in the European region focused on current perceptions concerning theater nuclear arms and an historical analysis of the German doctrine of attack against Soviet command, control and communication elements in the opening stages of the Battle of Barbarossa.

### ANALYSIS OF SOVIET MILITARY ACTIVITIES

Research of a very comprehensive nature was included in twelve papers delivered and discussed by a large number of Soviet experts at a three day conference on Soviet Decisionmaking for National Security held in August at the Naval Postgraduate School. It was jointly sponsored by the School and the Center of International and Strategic Affairs, U.C.L.A. Several publications resulted from the conference, including a book entitled Soviet National Security Decisionmaking to be published in 1981 by Johns Hopkins University Press.

#### MILITARY DECEPTION

Continuing interdisciplinary research in the areas of perceptions management and deception in international relations, negotiations and war has resulted in the identification of basic concepts which define strategic deception and its variants. A forthcoming technical report will synthesize, extrapolate, and summarize the conclusion of this group research project conducted over the past two years.

#### OPERATION TEST AND EVALUATION

Based on prior research conducted at NPS on the effectiveness of aircraft against tanks in World War II, the Department is continuing its participation in a major program of test and evaluation of the A-10 aircraft in low angle firings against simulated soviet tank battalions

#### MARITIME THEATER NUCLEAR WARFARE

The Department has also continued its research in an extensive review of U.S. Naval capabilities to operate effectively in a nuclear environment. At the request of the Chief of Naval Operations, the analysis this year has focused on the Theater Nuclear Warfare posture of the U.S. Navy.

Title: Effect of Islamic Culture on the Acceptance and Use of Western Cultural Items

Investigators: John W. Amos, II, Associate Professor, National Security Affairs and Ralph H. Magnus, Assistant Professor, National Security Affairs

Sponsor: Director of Net Assessment

Objective: To assess the impact of Islamic culture on:  
(1) Middle Eastern abilities to absorb and utilize Western military technology.  
(2) Middle Eastern abilities to utilize Western military organization, including command and control techniques.  
(3) Middle Eastern abilities to conduct Western-style military operations.  
(4) Middle Eastern abilities to innovate beyond the scope of transferred Western military technology and organization.

Summary: The project developed a general model of the interaction between Western innovation and Middle Eastern Islamic culture based on the culture change theories of B. Malinowski. Traits which help and hinder culture change in this culture are discussed, stressing the role of governments and institutions in the processes of change. Examples of Middle Eastern culture change are discussed and classified into the categories of "selective," "comprehensive" and "total," and the relationship of the Islamic institutions to each of these categories is discussed.

This phase of the project concludes that the real barriers that do exist in Middle Eastern Islamic culture to the successful adaptation of Western cultural items can be traced to specific failures in political, cultural and religious institutions, rather than to any generalized effect of Islam as a "drag on modernization."

Publication: J. W. Amos II, and R. H. Magnus, "Islamic Culture and Western Innovation: A General Model," NPS Technical Report, NPS56-80-015, October 1980.

Title: Regional Cooperation in Southern Africa

Investigator: Michael Clough, Adjunct Assistant Professor  
of National Security Affairs

Sponsor: NPS Foundation Research Program

Objective: To Analyze the prospects for successful  
regional cooperation in Southern Africa  
and to assess the implications for American  
policy toward the region.

Summary: Final conclusions have not been reached.  
Tentative results indicate that the current  
efforts of the Southern African Development  
Coordinating Conference (comprised of nine  
states) to promote regional economic develop-  
ment and reduced dependence on South Africa  
must overcome a number of obstacles if they  
are to succeed. Based on a review of pre-  
vious efforts to promote regional economic  
integration, it is unlikely that any large  
scale comprehensive schemes focussed on  
trade would have much chance of success.  
The major problem is determining how to  
distribute the costs and benefits of joint  
efforts. Inevitably, each state believes  
it is paying higher costs and receiving  
smaller returns than other participating  
states. For this reason, specific func-  
tional programs such as improvement of  
transportation networks offer the best hope,  
provided each state clearly recognizes the  
benefits it will derive from the project.  
Efforts to reduce dependency on South  
Africa are also likely to be difficult to  
carry out. Since the costs of reducing  
dependence will vary from state to state and  
given the lack of a ready source of funds to  
ease the short term burdens of reducing  
dependence on South Africa, any attempt to  
push too far, too fast is likely to fail.  
However, over the long term it is essential  
that these states reduce their dependence  
on South Africa for two reasons: 1) If  
there is large-scale civil unrest in South  
Africa and these states remain dependent on  
that state, they will be severely affected;  
and 2) Regardless of the composition of the

South African government, the surrounding states will need to reduce their dependence on that country in order to promote balanced economic development in their own countries. The evidence to date indicates that the nine members of the SADCC are proceeding cautiously and pragmatically.

Publications: A chapter co-authored by Michael Clough and John Ravenhill (Assistant Professor, University of Virginia) will appear in a book to be edited by Michael Clough that will be published sometime in 1981; another version of this paper may be published in World Development.

Conference Presentation: Paper presented to Zimbabwe Economic Symposium in Salisbury, Zimbabwe by Michael Clough on September 9, 1980.

**Title:** Battle of Wits: Synthesizing and Extrapolating from NPS Research on Strategic Military Deception

**Investigators:** D. C. Daniel, Associate Professor of National Security Affairs and K. L. Herbig, Adjunct Assistant Professor of National Security Affairs

**Sponsor:** Office of the Director of Net Assessment

**Objective:** To summarize the conclusions of the group research project on deception at NPS, January 1979 to May 1980, and the suggest additional views which resulted from this synthesis.

**Summary:** Definitions and descriptions of the basic phenomena of deception were presented. The process is examined from the deceiver's point of view, wherein the uncertainties and difficulties of doing deception successfully are identified, from the target's point of view, wherein most of the psychological and situational advantages are seen to fall to the deceiver, and from a historical perspective wherein the efficacy of using deception as a military policy is assessed.

**Publication:** NPS Technical Report, forthcoming.

Title: Multidisciplinary Perspectives on Military Deception

Investigators: D. C. Daniel, Associate Professor of National Security Affairs; K. L. Herbig, Adjunct Assistant Professor of National Security Affairs; W. Reese, Professor of Physics; R. J. Heuer, Adjunct Professor of National Security Affairs; T. R. Sarbin, Adjunct Professor of National Security Affairs; P. H. Moose, Assistant Professor of Electrical Engineering; R. G. Sherwin, Assistant Professor of National Security Affairs.

Sponsor: Office of Research and Develop, Central Intelligence Agency

Objective To advance understanding of the basic processes in strategic military deception through a group research program.

Summary: Basic concepts which define strategic deception and its variants were identified. The process of deception was overanalyzed using evidence from the recent past. Deception was found to be reliably advantageous to those who attempt it despite its susceptibility to unforeseen contingencies. Psychological biases of individuals and characteristics of organizations were identified which may lend themselves to being deceived. Feedback was identified as a key element and system theory were applied to deception to clarify the countering deception and for further research in these areas were put forth.

Publications: D. C. Daniel and K. L. Herbig, eds., "Multidisciplinary Perspectives on Military Deception," NPS Technical Report, NPS56-80-012, May 1980.  
D. C. Daniel and K. L. Herbig, "Propositions on Military Deception," Journal of Strategic Studies, forthcoming, 1981.  
D. C. Daniel and K. L. Herbig, Strategic Military Deception, Pergamon Press, forthcoming, 1981.

- Conference  
Presentations:**
- D. C. Daniel and K. L. Herbig, "Deception in Military Affairs, Propositions for Historical Analysis," at University of Lund, Lund, Sweden, 17-19 September 1979.
- D. C. Daniel and K. L. Herbig, "Propositions on Military Deception," International Studies Association, Los Angeles, California, 19-21 March 1980.

Title: The Economic Impact of Arms Transfers to Less Developed Countries with an Application to the Internal Economic Growth and Stability of Pre-Revolutionary Iran

Investigators: Robert Looney, Associate Professor, National Security Affairs, Edward Laurance, Associate Professor, National Security Affairs and Peter Frederiksen, Associate Professor., D.R.M.E.C.

Sponsor: NPS Foundation Research Program

Objective: The major objective is to develop a methodological framework capable of analyzing the economic implications of arms expenditures on the economies of less developed countries. This includes identifying those variables that are constraints or modifying economic growth in these countries, and the impact of defense expenditures on those constraints.

Summary: The research program has a number of inter-related facets. On a worldwide level data for over one hundred developing countries are being analyzed by cluster and discriminant analysis for patterns of defense expenditure and economic growth. Preliminary results for a smaller sample indicated that developing countries tend to fall into two major groups, one where increased defense expenditure apparently aids income growth (or at least is no impediment to expansion) and another where added defense expenditures appear to retard growth. In particular, we are examining whether the post-OPEC price increase period has fundamentally changed these relationships, and if so in what manner. To obtain a more precise picture as to the mechanism by which defense expenditures impact on a developing country, we have built full-scale macro-economic models for Mexico, Saudi Arabia, and Iran. In each model defense expenditures have been incorporated as a policy variable and an impact matrix computed. Preliminary results are consistent with worldwide findings; i.e., that resource constrained countries (Iran

and Mexico) must divert resources from economically productive activities to expand defense expenditures where resource unconstrained countries (Saudi Arabia) suffer no adverse effects in this regard and in fact derive positive side benefits from added military expenditure.

Finally, we are examining one country, Iran in great detail to obtain a better understanding of the interrelationship between political, economic and military decision making in developing countries. That work is specifically attempting to identify the role of defense expenditures in causing mass alienation and a revolutionary environment. Preliminary results indicate that Iran is a classic case of Gerr's theory of revolutions.

Preliminary results have been encouraging, and we plan on both expanding our scope and seeking outside funding--ACDA in particular.

**Publication:**

A paper with our initial model and results on defense expenditures and economic growth was submitted to Economic Development and Cultural Change. Apparently three reviewers have recommended its publication (with changes), but we have not received final confirmation.

**Conference**

**Presentations:**

Our initial results were presented at the Atlantic Economic Association Meetings, Boston, October 12, 1980.

Our further findings were presented at the Southern Economic Association Meetings, Washington, DC, November 5, 1980.

Title: Afghanistan: From Independence to Occupation

Investigators: Ralph H. Magnus, Assistant Professor of National Security Affairs, Faiz M. Khairzada Cornish Institute of the Arts, Seattle, Washington. (Formerly Deputy Minister of Information and Culture, Government of Afghanistan).

Sponsor: None

Objective: The contract is for the writing of a 350 page history of modern Afghanistan from the achievement of independence from a British protectorate over Afghan foreign relations as a result of the Third Afghan War of 1919 to the attempt to extinguish that independence currently in progress as a result of the internal coup d'etat of April 1978 and the Soviet invasion of December 1979.

Summary: This study will emphasize the internal dynamics of Afghan politics, including the continued strength of traditional forces, the innovative role of the educated elite and the crucial role of political leadership from the central government as a balance.

The intimate interactions between major domestic political orientations and foreign policies, especially with regard to the USSR and the West (Great Britain and the United States) will be investigated to illuminate the origins and growth of Afghan Marxism and constitutionalism.

Publication: Publication contact with Westview Press, Boulder, Colorado.

**Title:** International and Intranational Events in Africa: Computerized Indications and Warnings

**Investigator:** Ronald G. Sherwin, Adjunct Assistant Professor of National Security Affairs

**Sponsor:** Defense Advanced Research Projects Agency

**Objective:** Develop computerized I&W techniques to warn of domestic and international upheavals in Africa. Create data set for I&W and policy analysis. Incorporate techniques and software into NPS curriculum . Help make techniques available to operational intelligence agencies.

**Summary:** Research objectives have been met. Software is being installed at Eucom, IPAC, and NPS C<sup>3</sup> Lab.

**Publications:**

- R. G. Sherwin, "A Computerized Aid for International Crisis Management," Journal of Technology Transfer, 5, 1 Fall 1980.
- R. G. Sherwin, "Monitoring Political Strife in Sub-Saharan Africa: Testing an I&W System," December 1980.

**Theses Directed:**

- Richard M. Brown, "INTREP: A computerized Aid to Intelligence Data Retrieval and Analysis," Master's Thesis, December 1980.
- Charles Manro, "Indication and Warning Intelligence in Africa: Evaluation of a Quantitative Model," Master's Thesis, December 1980.

Title: German Disruption of Soviet C<sup>3</sup> in the Opening Stages of Barbarossa

Investigators: Russell H. S. Stolfi, Associate Professor of National Security Affairs, Lonnie Ratley III., Major U.S. Air Force

Sponsor: Office of the Secretary of Defense and Director of Net Assessment

Objective: To ascertain whether or not the Germans had a formal doctrine of attack against Soviet C<sup>3</sup> in the opening stages of Barbarossa (June, July 1941) and to describe and explain the description achieved.

Summary: The research support a view that the Germans did not have a specific formal doctrine of attack against Soviet C<sup>3</sup> in Barbarossa. The research shows, however, that the Germans achieved immense disruption of Soviet C<sup>3</sup> by a noteworthy combination of strategic circumstance, historical style, and combat technique which is elaborated upon in the research report.

Publication: A report approximately 250 pages in length has been sent to the research sponsor and is presently under review.

Thesis  
Directed: John Francis O'Neill, Jr., "German Counter-C<sup>3</sup> Activity and Its Effects on Soviet Command, Control, and Communications During Operation Barbarossa," Master's Thesis, March 1980.

**Title:** Lot Acceptance Verification Program,  
Airborne

**Investigator:** Russell H. S. Stolfi, Associate Professor  
of National Security Affairs

**Sponsor:** A-10 System Program Office

**Objective:** To evaluate the performance of existing  
production lots of GAU-8 ammunition when  
fired from the air under operational  
conditions.

To evaluate the lethality of GAU-8 ammu-  
nition against armored targets when fired  
at low level from A-10 aircraft using  
operational tactics.

**Summary:** The research technique, which is being  
employed, is unique in a well traveled area  
of experiment and analysis. Vulnerability  
is conventionally approached in terms of  
meticulously controlled experiment and  
associated complex models of damage effects.  
The LAVP-Airborne testing in challenging  
contrast uses actual main battle tanks  
loaded with sensitive items to include  
main gun ammunition, fuel, oil, and crew  
manikins as targets in conjunction with  
tactically executed aircraft attacks to  
ascertain the vulnerability of the targets  
lethality of attacking munitions, and the  
realism of the tactics employed in the  
attack. To date, the research team has  
conducted approximately 375 firing passes  
by A-10 aircraft at 375 combat loaded  
main battle tanks. The research has resulted  
in (1) changes to the Joint Munitions Effec-  
tiveness Manual for probabilities of kill  
by A-10 gun munitions against main battle  
tanks, (2) redesign of GAU-8 armor pierc-  
ing projectiles, and (3) employment of  
short firing bursts at close ranges and  
low dive angles as effective attack tech-  
niques.

**Publications:** R. H. S. Stolfi, "A-10/GAU-8 Low Angle Firing  
Versus Simulated Soviet Tank Company (Array  
17) (14 August 1979)," NPS Technical  
Report, NPS56-80-004, April 1980.

R. H. S. Stolfi and R. R. McEachin,  
"A-10/GAU-8 Low Angle Firings Versus  
Simulated Soviet Tank Company (Array 18)  
(30 August 1979)," NPS Technical Report,  
NPS56-80-005, May 1980.

R. H. S. Stolfi and R. R. McEachin,  
"A-10/GAU-8 Low Angle Firings Versus  
Simulated Soviet Tank Company (Array 20)  
(19 September 1979)," NPS Technical Report,  
NPS56-80-006, May 1980.

R. H. S. Stolfi and R. R. McEachin,  
"A-10/GAU-8 Low Angle Firings Versus  
Simulated Soviet Tank Company (Array 21)  
(30 October 1979)," NPS Technical Report,  
NPS56-80-007, May 1980.

R. H. S. Stolfi and R. R. McEachin,  
"A-10/GAU-8 Low Angle Firings Versus  
Simulated Soviet Tank Company (Array 22)  
(7 November 1979)," NPS Technical Report,  
NPS56-80-008, June 1980.

R. H. S. Stolfi and R. R. McEachin,  
"A-10/GAU-8 Low Angle Firings Versus  
Simulated Soviet Tank Company (Array 23),  
(15 November 1979)," NPS Technical Report,  
NPS56-80-009, June 1980.

R. H. S. Stolfi and R. R. McEachin,  
"A-10/GAU-8 Low Angle Firings Versus  
Simulated Soviet Tank Company (Array 26),"  
NPS Technical Report, NPS56-80-010,  
October 1980

R. H. S. Stolfi and R. R. McEachin,  
"A-10/GAU-8 Low Angle Firings Versus  
Simulated Soviet Tank Battalion (Array 3)  
(2 February 1979)," NPS Technical Report,  
NPS56-80-011, August 1980.



THE DEPARTMENT OF NATIONAL SECURITY AFFAIRS HAS SPONSORED RESEARCH PROJECTS WHICH INCLUDE THE DESIGN AND EXECUTION OF REALISTIC FIRING TESTS TO GAUGE THE EFFECTS OF USAF MUNITIONS AGAINST MODERN MAIN BATTLE TANKS. ONE SUCH PROJECT IS THE LOT ACCEPTANCE VERIFICATION PROJECT, CONDUCTED BY ASSOCIATE PROFESSOR RUSSEL H. STOLFI. SHOWN ABOVE IS A TARGET TANK HIT HARD BY 30MM GUN PROJECTILES FIRED FROM USAF A-10 AIRCRAFT EMPLOYED IN AN ATTACK AGAINST TEN SUCH TANKS USED TO SIMULATE AN ENTIRE SOVIET TANK COMPANY IN THE NEVADA DESERT.

Title: Communist Countries and Africa

Investigators: Jiri Valenta, Associate Professor of National Security Affairs and Dr. D. Albright, Senior Editor for Problems of Communism

Sponsor: NPS Foundation Research Program

Objective: To revise, update and edit an anthology which would assess the military involvement of communist countries in Africa. This study stems from and is the continuation of an earlier project.

Summary: This project continues to advance as each contributor updates and revises his respective chapter in the anthology. The principal investigator, J. Valenta has rewritten and updated a chapter of the book which he is editing with D. Albright.

Publications: J. Valenta and D. Albright (eds.), Communist Countries and Africa (Bloomington: Indiana University Press, 1981).  
J. Valenta, "The Communist Countries and the Horn of Africa," J. Valenta and D. Albright, (eds.), Communist Countries and Africa (Bloomington: Indiana University Press, 1981).  
J. Valenta, "Soviet-Cuban Intervention in Ethiopia, 1978," Journal of International Affairs, Vol. 34, No. 2, January 1981.  
J. Valenta and S. Butler, "East German Policies in Africa," Eastern Europe and the Third World (New York: Praeger Press, 1981).

Theses  
Directed: S. Butler, "Brotherhood-in-Arms: East German Foreign Policy in Africa," Master's Thesis, June 1980. (Recipient U.S. Naval Institute Award. Graduated with Distinction).

W. Nurthen, "Soviet Strategy in the Red  
Sea Basin," Master's Thesis, March 1980.  
(Recipient U.S. Naval Institute Award.  
Graduated with distinction.)

R. Mahlum, "U.S. Foreign Policy in Southern  
Africa," Master's Thesis, June 1980.

Title: Soviet Decisionmaking for National Security

Investigators: Jiri Valenta, Associate Professor of National Security Affairs and Dr. William Potter, Assistant Director for the Center of International and Strategic Affairs at UCLA

Sponsor: NPS Foundation Research Program

Objective: To assemble papers and edit an anthology which would assess Soviet decisionmaking for national security, a subject previously explored in the investigator's book Soviet Intervention in Czechoslovakia, 1968: Anatomy of a Decision (Baltimore: Johns Hopkins University Press, 1980). To convene a three day conference on August 14-16, 1980 for the presentation of invited papers by leading national and international experts on the subject.

Summary: The conference fulfilled the stated objective of bringing together a large number of experts, twelve of whom delivered papers. NPS students enrolled in the area program assisted with the organization of the conference. The principal investigator, J. Valenta served as co-director of the conference, wrote and presented a paper, chaired one of the conference panels, and will co-edit the proceedings of the conference.

Publications: J. Valenta and W. Potter (eds.), Soviet National Security Decisionmaking (Baltimore: Johns Hopkins University Press, 1981).

J. Valenta, "Soviet Decisionmaking and National Security: A Comparison of the Czechoslovak and Afghan Invasions," J. Valenta and W. Potter (eds.), Soviet National Security Decisionmaking (Baltimore: Johns Hopkins University Press, 1981).

J. Valenta, "Czechoslovakia and Afghanistan: Comparative Comments," Studies in Comparative Communism, Vol. XIV, No. 4, Winter 1980.

Theses  
Directed:

T. Milton, "Succession in the USSR,"  
Master's Thesis, June 1981.

T. Wyckop, "The Legacy of Ideology in  
Soviet Foreign Policy toward the West,"  
Master's Thesis, June 1981.



THE PANEL PICTURED ABOVE WAS CHAIRED BY PROFESSOR JIRI VALENTA AT THE CONFERENCE ON SOVIET DECISION-MAKING FOR NATIONAL SECURITY. AMONG THE PARTICIPANTS ARE: AMBASSADOR RAY GARTHOFF, PROFESSOR ALEX GEORGE (STANFORD UNIVERSITY), PROFESSOR CHARLES GATI (COLUMBIA UNIVERSITY), PROFESSOR PETER VIGOR (ROYAL MILITARY ACADEMY, SANDHURST, ENGLAND), PROFESSOR DONALD DANIEL (NAVAL POSTGRADUATE SCHOOL) AND ADMIRAL HORELIK (C.I.A. INTELLIGENCE OFFICER FOR THE SOVIET UNION).

Title: Soviet Intervention in Afghanistan

Investigator: Jiri Valenta, Associate Professor of National Security Affairs

Sponsor: None

Objective: To assess the soviet military intervention in Afghanistan. Interest in this subject stems from and is related to an earlier research project on the Soviet military involvement in the Third World.

Summary: The results of this study indicate a new assertive pattern in Soviet behavior characterized by military involvement in the Third World. Although also motivated by internal concerns and fears about instability in Afghanistan, the invasion came about mainly as a result of this trend. Other related factors were qualitative improvement in Soviet air-lift capabilities, Soviet strategic objectives in South Asia, and accurate Soviet assessment of U.S. responses. There is a likelihood that if not countered, Soviet military aggression may be repeated in other strategically important areas of the Third World, e.g., Iran and/or Pakistan.

Publications: J. Valenta, "From Prague to Kabul: The Soviet Style of Invasion," International Security, Vol. 5, No. 2, Fall 1980, pp. 114-141.

J. Valenta, "The Soviet Invasion of Afghanistan: The Difficulty of Knowing Where to Stop," ORBIS, Vol. 24, No. 2, Summer 1980, pp. 201-218.

A. Dallin, V. Aspaturian and J. Valenta, The Soviet Invasion of Afghanistan: Three Perspectives (Los Angeles: Center for International and Strategic Affairs, UCLA, 1980), 71 pages.

Thesis  
Directed: N. Hasson, "Demographics, Economics, and the Soviet Armed Forces: Implications for U.S. National Security Policy," Master's Thesis, December 1981.

Title: Soviet Policies Toward Hungary and Czechoslovakia

Investigator: Jiri Valenta, Associate Professor of National Security Affairs

Sponsor: Council on Foreign Relations

Objective: To evaluate Soviet policies toward Hungary and Czechoslovakia in the 1970s; to assess overall Soviet policies vis-a-vis the Warsaw Pact countries.

Summary: This research indicates that the Soviets, by employing various different policy instruments, have been able to succeed in maintaining the traditional Warsaw Pact control structure in both countries. Following the Polish revolution of 1980, however, these states may undergo political changes. Much will depend on the resolution of the Polish crisis.

Publications: J. Valenta, "Soviet Policy toward Czechoslovakia and Hungary," S. Terry (ed.), Soviet Policy in Eastern Europe (New York: Council on Foreign Relations, 1981), 40 pages.

J. Valenta and C. Rice, "Czechoslovak Armed Forces," J. Adelman (ed.) Armed Forces in Communist Societies (Denver: Westview Press, 1981).

J. Valenta, "The Workers in Czechoslovakia: Proletariat Embourgeois?" J. Triska and C. Gati (eds.), Labor in Eastern Europe (London: Allen and Unwin, 1981).

Theses  
Directed:

R. Harrick, "Self Defense in Yugoslavia," Master's Thesis, March 1980.

D. Fraze, "Yugoslav Territorial Defense," Master's Thesis, June 1982.

K. Grunwald, "USSR and Polish Crisis," Master's Thesis, June 1982.

Title: The USSR and Cuba in the Caribbean Basin

Investigator: Jiri Valenta, Associate Professor of National Security Affairs

Sponsor: Office of Net Assessment

Objective: To assess the Soviet and Cuban military involvement in the Caribbean and Central America; to further the knowledge of Soviet and Cuban strategies and military policies in this region; to suggest policy options for the United States.

Summary: The investigator's research on this subject--which comes extensively from Soviet, Cuban and Central American sources--indicates a new assertive pattern in Soviet and especially Cuban behavior. Such behavior is characterized by military involvement in the Third World and in the Caribbean basin in particular. This topic calls for further careful examination to be followed by a lengthy report.

Publications: J. Valenta, "The Soviet-Cuban Alliances in Africa and Future Prospects in the Third World," Cuban Studies/Estudios Cubanos (Center for Latin American Studies, University of Pittsburgh, Pittsburg, Penn.), July 1980, Vol. 10, No. 2 (special volume II), pp. 36-43.

J. Valenta, "The USSR and Cuba in Africa and the Caribbean Basin," The World Today (London, England), March 1981.

Title: French and Soviet Perspectives on Theater Nuclear Policy and Arms Control

Investigator: David S. Yost, Adjunct Assistant Professor of National Security Affairs

Sponsor: NPS Foundation Research Program

Objective: Advance understanding of NATO interests and perceptions regarding possible theater nuclear arms control negotiations.

Summary: The first phase of this project (Summer 1980) focused primarily on France (in the context of NATO Europe in general), while the second phase (winter or spring 1981) will focus on the Soviet Union. Results so far have clarified West European perceptions of SALT II and SALT III issues, including the arguments of West European supporters and critics of SALT II. Moreover, the complex internal debate in France regarding relevant defense issues has been thoroughly analyzed.

Publications:

- D. S. Yost, "Beyond SALT II: European Security and the Prospects for SALT III," in Orbis, 24, 3 (1980).
- D. S. Yost, "The French Defense Debate: Schools of Thought and Probabilities," in Survival, 23, (1981).
- D. S. Yost, "SALT and European Security," in D. S. Yost, ed. NATO's Strategic Options: Arms Control and Defense (New York: Pergamon Press, 1981).
- D. S. Yost, Der SALT-Prozess und die sicherheitspolitische Lage Westeuropas (Sankt Augustin/Bonn, West Germany: Konrad-Adenauer-Foundation, 1980).
- D. S. Yost, review article on 2 new French books on European security, in Survival, 22 (1980).

## DEPARTMENT OF PHYSICS AND CHEMISTRY

A major part of the FY 1980 research effort continues to be interdisciplinary in nature, involving colleagues from other departments and students from a number of different curricula. As in the previous year, studies of the interface between man-made systems and their functioning in a non-manipulative environment form a theme common to much of the Department's effort.

As described in the following, new evolutions in the research areas are evident this year. The Electron Linear Accelerator (LINAC) effort has moved away from nuclear physics and into the production and study of transition radiation and stimulated electromagnetic shock radiation. Research in geomagnetic phenomena is increasing. Plasma research has shifted to a study of plasma-surface effects. The electro-optics effort joined with the efforts of the Environmental Physics Groups for a long-term field experiment. We have introduced a new category of effort which we call Defense Sciences, under which we gather efforts related to physical weapons effects or analyses of whole weapons systems. A growing effort here was the development of analytical models of C<sup>3</sup> systems using concepts from statistical thermodynamics.

### NUCLEAR PHYSICS

The Electron Linear Accelerator (LINAC) has been used for radiation experiments and some nuclear physics. The applied nuclear project initiated by F. R. Buskirk with D. Coyne (Princeton), is aimed at investigating the properties of a new scintillation detector, bismuth germinate, which can replace sodium iodide crystals in many X-ray and gamma ray detectors. Advantages include smaller detector volume and much greater durability of the crystal, while sacrificing only slightly the energy resolution of the established sodium iodide system. Experiments at the LINAC aim at measuring the energy resolution of these crystals in the energy range of 30 to 100 MeV.

### TRANSITION RADIATION

Electrons passing through thin foils produce X-rays, which result from the sudden discontinuity in the dielectric constant at the boundary. Experiments conducted by F. R. Buskirk, M. A. Pietstrup and R. Pantell (Stanford) at the LINAC have demonstrated that 100 MeV electrons produce a narrow beam (about 1/2° width) concentrated at X-ray energies

of several kilovolts. Two publications have resulted and further experiments are planned. Applications of this type of source to X-ray lithography are being considered where the short wave length could produce patterns with a resolution well under one micron. Very small microcircuits are an obvious application.

#### COHERENT RADIATION FROM RELATIVISTIC ELECTRONS

Fast electrons moving to the right against an incoming electromagnetic wave (moving to the left) experience a transverse oscillation. Radiation produced in the forward direction by the oscillating electron is doppler shifted to short wave lengths. Large doppler shifts occur even if the incoming wave is replaced by a static periodic magnetic field (wiggler) through which the electrons move, and the free electron laser is a noted example using these principles.

Experiments conducted by F. R. Buskirk, M. A. Piestrup, and R. Spitzer at the LINAC involved the test of a theory called "Stimulated Electromagnetic Shock Radiation," in which large radiation effects were predicted by combining the effects of a wiggler magnet array and passing the electrons through a gas such that Cerenkov radiation is present. The experiments show a small modification to Cerenkov radiation produced by the wiggler array. Further experiments will attempt to measure the "side bands" predicted by various theories.

#### GEOMAGNETIC PHENOMENA

O. Heinz and P. Moose, in cooperation with E. C. Crittenden, are continuing their work on ambient magnetic field fluctuations.

The objective of this project is to obtain improved long term data on, and identification of, sources of electromagnetic signals on the ocean floor. By using a combination of total field magnetometers and directional antennas, the frequency range from a few millihertz to several hertz is covered. A series of measurements were carried out on the floor of Monterey Bay in water depth ranging from 30 to 300 meters. An optically pumped Cs vapor magnetometer and a set of coils and associated electronic and recording equipment were deployed from the Research Vessel ACANIA in a self-contained instrumentation package. A remote land site is also being instrumented to provide real time comparison data.

## LASER AND PLASMA PHYSICS

F. Schwirzke continued his investigation of laser produced plasmas with emphasis shifted to the study of plasma-surface effects. Unipolar arcing occurs if the sheath potential between plasma in contact with metal surface is high enough. It represents one of the most damaging plasma-surface interaction processes which influences the performance and lifetime of components like switches, electrodes, etc., of high power plasma devices.

In FY 80 the Air Force Weapons Laboratory sponsored a study on arc-phenomena in a high-power e-beam sustained CO<sub>2</sub> laser. A cooperative effort with DoE supported fusion research at UCLA continued. Of special interest is the resiliency of metals and protective coatings to damage by plasma-wall contact and arcing.

## ATOMIC PHYSICS

Our Spectroscopic Data Center directed by R. Kelly continues its long range program of providing definitive compilations of data. A compilation stored on magnetic tape of all lines for the first 18 elements for all stages of ionization has been completed and submitted for publication. Work on the compilation of all lines below 2000 Å for the first 36 elements is in progress with support from NBS. A special compilation of 30000 lines for the first 36 elements in the 2000 - 3000 Å region has been completed and published in support of NASA's space exploration and solar physics program.

## SURFACE PHYSICS

D. E. Harrison, Jr., with support from the National Science Foundation and two collaborators from the Pennsylvania State University, has continued to investigate the ion impact analysis of clean and chemically reacted single crystal metal surfaces by classical trajectory computer simulation methods.

## ELECTRO-OPTICS

Research concerning the optical properties of the atmosphere with E. C. Crittenden, A. W. Cooper, E. A. Milne, G. W. Rodeback and R. L. Armstead and participating students, has continued. A long-term field experiment (MAGAT-80) was carried out on Monterey Bay involving land-to-land transbay multiwavelength optical measurements of extinction and scintillation. The work was concurrent with meteorological and micrometeorological measurements made by the Environmental

Physics Group employing the R/V Acania, aircraft and satellite. The experiment verified models of turbulence and aerosol generation developed by the group. Work has also continued at China Lake in joint experiments with Pt. Mugu concerning the properties of the atmosphere during tests of military electro-optic equipment.

An unsponsored study has been continued by A. W. Cooper and students on development of hand-held calculator and micro-computer programs for FLIR performance prediction.

An unsponsored program for measurement of small variations of the earth's magnetic field has been carried out by E. C. Crittenden and students, utilizing a fiber optic interferometer system, in which variation in length of one of a pair of matched single mode fibers is caused by magnetostriction in an amorphous metal film.

#### ENVIRONMENTAL PHYSICS

Professor Schacher and K. Davidson have continued their efforts on modeling the marine boundary layer with special emphasis on the coupling between the surface layer fluxes and dynamics of the full boundary layer. In this area current projects address:

- Effect of Turbulence on Optical Propagation
- Optical Extinction by Aerosols
- Overwater Transport and Dispersion
- Boundary Layer Modeling

The second general area is air-sea interaction. They are looking in detail at wind wave coupling with special emphasis on hydrostatic stability effects. The specialized topics of interest are:

- Microwave Backscatter from the Sea Surface
- Marine Aerosol Generation

AY 80 efforts have involved one cruise on Monterey Bay to validate the bulk aerodynamic method for predicting optical scintillation, one cruise to the North Pacific to investigate air sea interaction during storms, and two cruises to do tracer experiments for transport studies. The bulk method has been well validated and major work on the aerosol contribution to optical extinction has been completed. A full boundary layer model for aerosol content is being validated. Analysis of data for transport and dispersion parameterization is in the early stages.

## UNDERWATER ACOUSTICS

A. Coppens and J. V. Sanders and students have continued their theoretical and experimental investigation of the transmission of acoustic energy from an ocean of decreasing depth into a fast bottom. Theoretical calculation has been streamlined and new experiments are being planned. H. Dahl has pursued his development of Ray Tracing Algorithms for the accurate positioning of sound sources for the underwater acoustic range of the Naval Undersea Warfare Station. H. Medwin with his students investigated ocean parameters affecting sound propagation along several lines including near grazing scattering of sound from rough surfaces and acoustical shadowing by seamounts. O. B. Wilson, with colleagues from several other departments, has continued his work on long range problems for the Naval Undersea Warfare Engineering Station, Keyport, Washington. This included work on measuring the predicting acoustic properties of sediments on Keyport's weapons test ranges. Also, with students, work on transducers and underwater acoustic measurements was done.

In collaboration with Professor Sackman and several students, O. B. Wilson made measurements of the array gain of a vertical line array in the Santa Cruz Basin at the Santa Cruz Island Acoustic Range Facility (SCARF).

## ACOUSTICS

O. B. Wilson and students pursued the development of a 75khz transducer which makes use of flexural waves on a flash mounted plate and which is to be used on acoustic tracking ranges.

H. Medwin conducted computer studies of the shadowing by finite noise barriers and infinite wedges and plates.

A. B. Coppens and J. V. Sanders have continued studies of finite amplitude standing waves in cavities with perturbed walls with perturbing results.

J. V. Sanders and a student studied the noise produced in water by both free-falling spheres and spheres constrained to move in a straight line.

## DEFENSE SCIENCES

Under this heading all Department efforts related to either physical weapons effects or analysis of whole weapon systems are collected. W. Reese has continued his support for the Naval Intelligence community. Together with members

from the NSA Department, he was involved in a comparative analysis of major Soviet Fleet exercises, and open literature technical forecast study and the development of a threat forecasting methodology.

R. A. Reinhardt and G. F. Kinney have continued their theoretical investigations of internal blast phenomena. Their thermodynamic calculations are directed toward determination of overpressures resulting from explosions in confined spaces. The scope of these investigations has been enlarged by including the effects of a reactive metal component.

Professors Moose and Woehler have continued a low level effort which was funded originally by the Director of Net Assessment in OSD and then by DARPA in FY 80. The effort is directed at developing analytical models of whole C<sup>3</sup> systems using concepts from statistical thermodynamics.

Title: Stimulated Electromagnetic Shock Radiation  
Demonstrated Experiment

Investigators: F. R. Buskirk, J. N. Neighbours, J. N. Dyer,  
Professor's of Physics and Chemistry;  
W. Zeleny, Associate Professor of Physics  
and Chemistry, and R. Spitzer (Stanford)

Sponsor: Office of Naval Research

Objective: To measure the radiation produced when electrons passing through a gas under Cerenkov conditions, have an oscillating motion superposed perpendicular to their linear, relativistic motion.

Summary: This series of experiments has been initiated to verify predictions made by S. Schneider and R. Spitzer for the radiation produced by electrons which are moving in a medium under Cerenkov conditions, with the addition of transverse oscillation of the beam caused by a static or travelling wave wiggler field. Magnetic wigglers are being investigated, because a very high power microwave beam, 20 megawatts in the S Band, will produce the same affect as a 50 gauss static, spatially periodic wiggler field. Two wigglers are being pursued.

1. Iron Core Wiggler. This produces a field amplitude of up to 1.5 k gauss, D.C., period = 8 cm and a gap width of 2 cm.

2. Pulsed Spiral Wiggler. A pulsed spiral arrangement with geometry similar to the superconducting spiral used in the Stanford F.E.L. experiments is being developed.

The iron core wiggler has been installed and is under test. Quantitative measurements of the radiation produced must overcome an unexpected problem: net deflection is given to the electron beam when the magnets are turned on, so that comparison of shock radiation [magnet on and Cerenkov (magnet off)] are not yet quantitative.

Thesis  
Directed: W. M. Decker, and J. P. Mackin, "Measurements of Pumped Superluminal Electromagnetic Radiation, Master's Thesis, June 1980.

Title: Experimental Study of a Saturated Parametric Array in Air

Investigators: Alan B. Coppens, Associate Professor of Physics and Chemistry, and LT Stephen Trenchard, United States Coast Guard

Sponsor: This research derives in part from funds made available to LT Trenchard by the US Coast Guard, (Ocean Engineering Branch)

Objective: To study the behavior of a parametric array in air when the primary source levels are high enough to lead to "saturation", and compare the results with the Moffett-Mellen design curve predictions developed for use in water both which should be valid for air also.

Summary: The experiments confirmed the Mellen-Moffett design curves, and also revealed a way of driving the array of sources to avoid intermodulation distortion at the source which would interfere with the parametrically-generated difference frequency: The array of sources was split into two interlaced subarrays, each of which was excited separately with one of the two primary frequencies.

Publication: A letter has been submitted and accepted for publication in the October 1980 issue of Journal of Acoustic Society American.

Thesis  
Directed: Stephen Trenchard, "Experimental Study of the Radiation Properties of a Parametric Fog Horn," Master's Thesis, September 1979.

Title: Simple Speed of Sound Formulas for Neptunian Waters

Investigator: Alan B. Coppens, Associate Professor of Physics and Chemistry

Sponsor: None

Objective: To develop simple expressions for calculating the speed of sound in ocean waters, including special cases such as the Sulu Sea, Baltic, Mediterranean, Black, and Persian Gulf.

Summary: A Wang 2200 computer was used to reduce an elaborate equation of high precision developed by Lovett (J. Acoust. Soc. Am. 63, 1713 (1978)), following the innovative approach of Leroy (J. Acoust. Soc. Am. 46, 216 (1969)). The resultant equation, containing few terms and relatively simple coefficients, lies within a few cm/sec of the predictions of Lovett's equation.

Publication: A letter has been submitted and accepted for publication in the J. Acoust. Soc. Am. It is scheduled for the January issue.

Title: Measurement of the Effects of Turbulence on Airborne Optical Projectors

Investigators: E. C. Crittenden, Distinguished Professor of Physics & Chemistry, E. A. Milne, Associate Professor of Physics & Chemistry, A. W. Cooper, Professor of Physics & Chemistry, G. W. Rodeback, Associate Professor of Physics & Chemistry, and S. H. Kalmbach, Professor Emeritus of Physics & Chemistry.

Sponsor: Pacific Missile Test Center

Objective: Measurement of  $C_n^2$  on optical paths from aircraft to ground during tests, at China Lake, of the Compass Hammer device.

Summary: Measurements were carried out during a two-week field experiment at China Lake.  $C_n^2$  (the turbulence structure constant for optical index) was measured by means of MTF (Modulation Transfer Function), employing portable equipment developed at the Naval Postgraduate School. The results are obtained essentially in real time and printed out in a few minutes. These results were communicated immediately to the PMTC team at China Lake and used by them in subsequent utilization of the data which they had taken simultaneously on the Compass Hammer equipment. The experiments carried out this fiscal year were ground-to-ground measurements with equipment capable of operating in an aircraft-to-ground mode. Air-to-ground experiments are to be carried out during FY 81.

Publication: Data Print-outs submitted to the sponsor in tabular form.



PROFESSOR E. A. MILNE MAKING TURBULENCE  
MEASUREMENTS WITH THE MTF EQUIPMENT

Title: Optical Measurement of  $C_n^2$  for Comparison with Predictions

Investigators: E. C. Crittenden, Jr., Distinguished Professor of Physics & Chemistry, E. A. Milne, Associate Professor of Physics & Chemistry, A. W. Cooper, Professor of Physics & Chemistry, G. W. Rodeback, Associate Professor of Physics & Chemistry, and S. H. Kalmbach, Professor Emeritus of Physics & Chemistry.

Sponsor: Naval Environmental Prediction Research Facility

Objective: Measurement of  $C_n^2$ , the turbulence structure constant for optical index, by means of scintillation, along an optical path across Monterey Bay, continuously for a long period, for verification of predictive models to be developed by NEPRF.

Summary: Measurement of  $C_n^2$  was accomplished along a 13.2 km optical path from Marina to Pt. Pinos, by means of techniques developed in previous research programs. Scintillation was utilized because it weights the center of the optical path most heavily, permitting comparison with predicted values based on meteorological data for the center of the path. Data were taken and on-line processed with a minicomputer to give immediate results. Data taken continuously for a period of 15 days, and reported daily to NEPRF. Agreement with predictions was excellent. Companion data were also taken of the optical extinction at a number of wavelengths, for comparison with predictions. These results also agreed with model predictions.

Publications: E. C. Crittenden, Jr., E. A. Milne, A. W. Cooper, G. W. Rodeback, and S. H. Kalmbach, "Overwater Optical Scintillation Measurements during MAGAT-1980", NPS Technical Report, NPS-61-80-018, August 1980.

**Title:** Classical Trajectory Studies of Low Energy Ion Impact Mechanisms on Clean and Reacted Single Crystal Surfaces

**Investigators:** Don E. Harrison, Jr., Professor of Physics and Chemistry, K. E. Foley, B. J. Garrison, and N. Winograd, Pennsylvania State University

**Sponsor:** National Science Foundation and NPS Foundation Research Program

**Objective:** Continue study of the effects produced when ions bombard clean and chemically reacted single crystal metal surfaces to understand mechanisms and coordinate with experimental investigations.

**Summary:** Classical trajectory simulations have developed to the point that it is feasible to model the cascade produced by an ion impact event. The ability to follow each individual atom in the cascade leads naturally to pictorial interpretations of a single sputtering event. Statistical analysis of data produces numbers which can be directly compared to the experimental data. The model computations are done using single crystal targets oriented to expose the low index surfaces. Research effort this year has established that vacuum phase recombination of atoms is the preferred mechanism of molecular cluster formation. The energy distributions of sputtered atoms supports this interpretation. The influence of the ion-atom potential function on sputtering has also been examined. The sputtering yield has been shown to be a function only of the magnitude of the ion-atom potential function is a sensitive separation range.

**Publications:** N. Winograd, K. E. Foley, B. J. Garrison and D. E. Harrison, Jr., "Evidence for a Recombination Mechanism of Cluster Emission from Ion Bombarded Metal Surfaces," Physics Letters 73A(3), 253-55 (1979).

D. E. Harrison, Jr., "Atom Ejection Studies by Classical Trajectory Simulation," AIP

Conference Proceedings No. 61, Aspects of the Kinetics and Dynamics of Surface Reactions (La Jolla Institute-1979) ed. U. Landman, American Institute of Physics, New York, 1980., pp. 307-18.

D. E. Harrison, Jr., B. J. Garrison and N. Winograd, "Atom Ejection Mechanisms and Models," Secondary Ion Mass Spectrometry: SIMS II, ed. A. Benninghoven, et. al., Springer-Verlag New York (1979), pp. 12-14.

B. J. Garrison, N. Winograd and D. E. Harrison, Jr., "Classical Trajectory Calculations of the Energy Distribution of Ejected Atoms from Ion Bombarded Single Crystals," Surface Science 87, 101-111 (1979).

D. E. Harrison, Jr., "Full Lattice Simulations of Atom Ejection Mechanisms," Proceedings: Symposium on Sputtering, Perchtoldsdorf/Vienna, Austria, April 28-30, 1980, ed. P. Varga, et. al., pp. 36-61. (unpublished).

Conference

Presentations:

D. E. Harrison, Jr., "Full Lattice Simulations of Atom Ejection Mechanisms," Symposium on Sputtering, Perchtoldsdorf/Vienna, Austria, April 28-30, 1980.

**Title:** Spectroscopic Data Center Compilation of Atomic Energy Levels

**Investigator:** Raymond L. Kelly, Professor of Physics

**Sponsor:** NPS Foundation Research Program

**Objective:** To produce a useful, comprehensive, and semi-critical compilation of atomic energy levels, based on publications listing spectrum lines. The compilation is to be stored on magnetic tape, in order to be available to a large community of users, and is to be updated regularly on a continuing basis.

**Summary:** The initial phase of the compilation has been completed for the first 24 elements, Hydrogen through Chromium, for all stages of ionization. Such information makes possible classification of unidentified lines from plasma sources and in solar spectra, as well as the prediction of other lines (valuable in laser physics).

**Publications:** Raymond L. Kelly and Don E. Harrison, Jr., "Ionization Potential of Fe XVII in the Neon Isoelectric Sequence, Revised Value," Atomic Data and Nuclear Data Tables 19, 303-303 (1977).

**Conference Presentation:** Reported at VI International Conference on Vacuum Ultraviolet Radiation Physics, Charlottesville, VA, June 1980.

Title: Spectroscopic Data Center Compilations of Near Ultraviolet Spectra

Investigator: Raymond L. Kelly, Professor of Physics and Chemistry

Sponsor: National Aeronautics and Space Administration

Objective: To produce a critical compilation of long wavelength ultraviolet lines (wavelengths 2000-3000 Angstroms) in support of space exploration and solar physics, maintaining a current compilation on a continuous basis. The work is based on publications in the open literature.

Summary: The initial compilation of 30,000 lines, from the first 36 elements, has been completed. It has been stored on magnetic tape and published as a NASA Special Publication. Work has started on adding the classifications to each line as an extension of the initial compilation. This continuing project will be completed in three years. Included in the final compilation will be (for each spectrum line) wavelength, intensity, classification, and energy level for both the upper and lower state in the transition.

Publications: R. L. Kelly, "Atomic Emission Lines in the Near Ultraviolet; Hydrogen Through Krypton," NASA Technical Memorandum, 80268, April 1979.

Title: Spectroscopic Data Center Compilations of Vacuum Ultraviolet Spectra

Investigator: Raymond L. Kelly, Professor of Physics and Chemistry

Sponsor: Office of Standard Reference Data

Objective: Preparation of a critical compilation of atomic spectrum lines with wavelengths below 2000 Angstroms, for the first 36 elements. This is a continuing project.

Summary: Computer-based files are prepared containing the wavelength, intensity, and classification for all lines observed in solar or terrestrial sources. A complete file of atomic energy levels is maintained for calculation of wavelengths of predicted transitions. These wavelengths are critically compared with those reported in the literature and in unpublished communications. A new compilation has been completed for the first 18 elements and stored on magnetic tape, and submitted for publication. Completion of the final compilation is scheduled for 1983.

Title: Ocean Parameters Affecting Sound Propagation

Investigator: Herman Medwin, Professor of Physics and Chemistry

Sponsor: Office of Naval Research

Objective: To determine those oceanographic factors which affect the propagation and detection of sound at sea.

Summary: During FY 1980: 1) We completed our physical model study of diffraction by a seamount and provided the first successful prediction of the attenuation due to seamount shadowing, and its frequency dependence, at sea; 2) We demonstrated how the impulse diffraction technique can be used for accurate computer predictions of attenuation by a finite noise barrier and 3) Our computer model of scattering from the ocean surface clarified the conditions under which the range dependence of the backscattered intensity can vary from  $R^{-2}$  to  $R^{-4}$ .

Conference Presentations:

H. Medwin and R. Spaulding, "Shadowing by Seamounts," Journal of the Acoustical Society of America, 66, S76, 1979.

H. Medwin and R. Spaulding, "The Seamount as a Diffracting Body," Proceedings, Bottom-Interacting Ocean Acoustics Conference, SACLANTCEN, 1980. To be published by Plenum Press 1981.

H. Medwin, "Shadowing by Finite Barriers," Journal of the Acoustical Society of America, 67, p. 87, 1980.

H. Medwin and J. C. Novarini, "Rough Surface Backscatter with Secondary Diffraction and Without Kirchhoff Approximation," Journal of the Acoustical Society of America, 67, S67, 1980.

**Publications:** H. Medwin, "Shadowing by Finite Noise Barriers," accepted for publication, Journal of the Acoustical Society of America, 1981.

H. Medwin, and J. C. Novarini, "Back-scattering Strength and the Range Dependence of Sound Scattered from the Ocean Surface," accepted for publication in Journal of the Acoustical Society of America, 1981.

**Patents:** "Surface Acoustic Signal Defader," Inventor, H. Medwin; Assignee, U. S. Navy Patent Number 4,219,888 granted 26 August 1980.

"Acoustical Deverbator," Inventor, H. Medwin; Assignee, U. S. Navy, Patent Number 4,225,954 granted 30 September.

Title: Investigation of Geomagnetic Field Fluctuations on the Ocean Floor

Investigators: P. H. Moose, Associate Professor of Electrical Engineering, and O. Heinz, Professor of Physics and Chemistry.

Sponsor: Office of Naval Research, and Arms Control and Disarmament Agency

Objective: To determine the nature, level, spectra, spatial coherence, and origins of ULF electromagnetic fields at and near the sea floor.

Summary: This is a continuation of a project begun in 1978. In addition to the Cs-vapor magnetometer previously packaged for undersea use, a 6000 turn ULF coil antenna and low-noise amplifier system was designed, procured and packaged for underwater operations. Field tests in Monterey Bay show this to be an ideal sensor for the .5 to 25 Hz frequency range, thus augmenting the Cs-vapor magnetometer which operates well only at frequencies less than 3 Hz. Also, the coils measure field components in contrast to the Cs-vapor magnetometer, which measures total field strength. Thus we were able to verify experimentally the theoretical prediction that horizontal field components are much greater in magnitude than vertical components at the sea floor. Work has also begun on the problem of measuring sea-floor conductivity. The problem of finding a suitable magnetic component gradiometer for use in the sea will be addressed in the coming year. An undersea digital multichannel data logger is being developed with the assistance of APL/UW. It will record cassettes of  $10^6$  - 12 bit data samples over experimental periods up to 16 months. This equipment, including playback and decoding for readout, will be available for initial field testing in early 1981.

Thesis  
Directed:

E. J. Chaffee, "Low Frequency Geomagnetic Fluctuations (.01 to 3 Hz) on the Floor of Monterey Bay," Master's Thesis, December 1979.

G. R. McDevitt and B. B. Homan, "Low Frequency Geomagnetic Fluctuations (.04 to 25 Hz) on Land and on the Floor of Monterey Bay," Master's Thesis, June 1980.

Title: Internal Explosions Involving Reactive Metal Effects

Investigators: R. A. Reinhardt, Professor of Physics and Chemistry, and G. F. Kinney, Distinguished Professor Emeritus of Physics and Chemistry

Sponsor: Naval Weapons Center

Objective: A continuation of theoretical studies of pressure effects in the combustion of metal/fuel/air mixtures.

Summary: Calculations have been substantially completed for temperature, pressure and product yield resulting from the internal explosions of mixtures of magnesium or aluminum with various fuels and explosives under adiabatic conditions in air. Extension to systems containing both metals is anticipated for the future.

Publication: A report of the research, to be published by NWC China Lake, is in early stages of preparation.

**Title:** Finite-Amplitude Standing Waves in Real Cavities

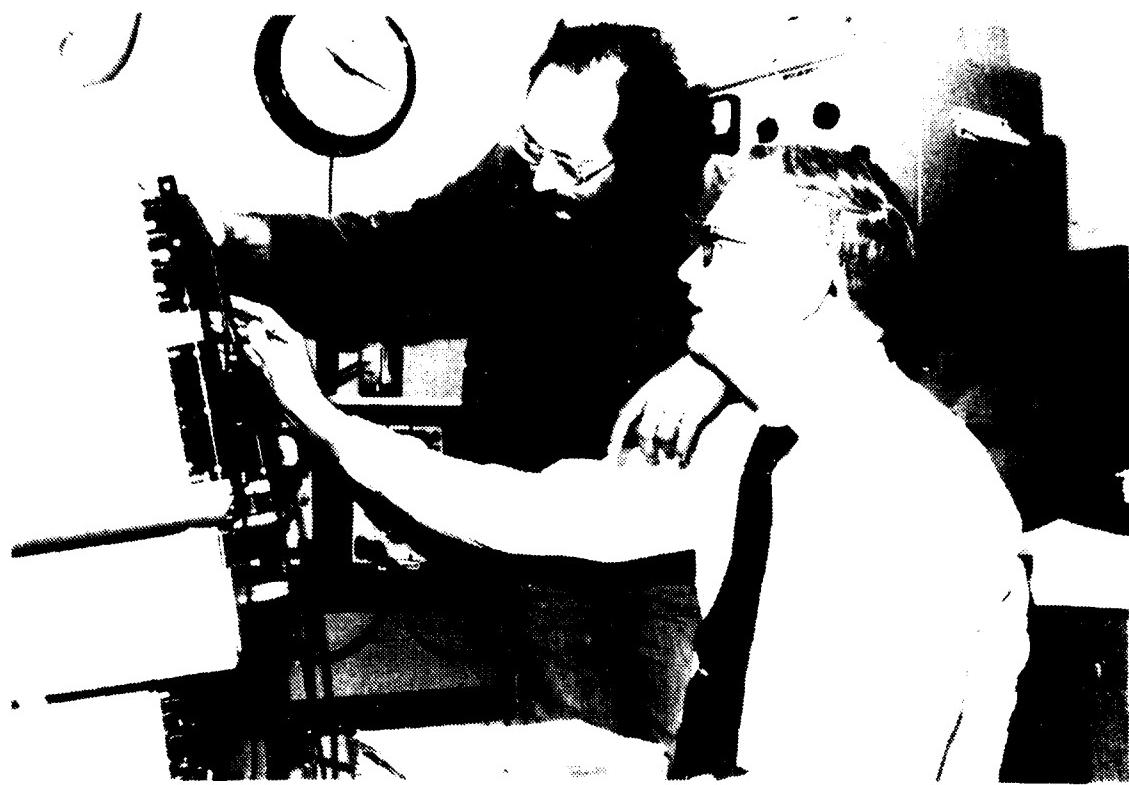
**Investigators:** J. V. Sanders and A. B. Coppens, Associate Professors of Physics and Chemistry

**Sponsor:** None

**Objective:** To identify the role of geometrical perturbations on finite-amplitude standing waves in rectangular cavities.

**Summary:** Several years ago, we worked out the theory of finite-amplitude standing waves in rectangular cavities of ideal geometry, and we experimentally verified the accuracy of the theory for cavities without degeneracies. Small, but significant discrepancies were noted when a mode not belonging to the family of driven modes was degenerate with one of the members of the driven family. The theory was then extended to account for the effects of geometrical perturbations as would be found in any real cavity. Attempts to experimentally verify this extended theory were qualitatively successful but the effects were so small that quantitative agreement eluded us. To provide more precision in an already precise experiment, the cavity was redesigned to allow even better control of all conditions. All the effort this year has been spent in developing the experimental expertise necessary to obtain suitably precise data and good enough to allow verification of the extended theory. We are now using the theory to predict what kind and size of perturbations will produce effects that can be measured with the precision now available.

**Thesis  
Directed:** Io-Bok Joung, "Finite-Amplitude Standing Waves in a Rectangular Cavity with Wedge Type Boundary Perturbation," Master's Thesis, December 1980.



PROFESSOR SANDERS AND PROFESSOR COPPENS  
INVESTIGATE THE FINITE AMPLITUDE  
BEHAVIOR OF STANDING ACOUSTIC WAVES  
IN A RECTANGULAR CAVITY.

**Title:** Hydrodynamic Noise Generated by Blunt Bodies

**Investigator:** James V. Sanders, Associate Professor of Physics and Chemistry

**Sponsor:** None

**Objective:** To identify and study the hydrodynamics of the sources of impulsive noise generated by a sphere moving through water.

**Summary:** It is known from previous experiments that freely falling spheres produce sudden noise bursts. The source of this noise is unknown and little is known about the conditions under which it occurs. In an attempt to study this phenomenon under controlled conditions, spheres were towed in an anechoic tank. Velocities up to 5 m/s and Reynolds numbers up to  $5 \times 10^5$  were obtained with spheres of 5.1, 10.2, and 25.4 cm diameters. After eliminating all mechanical and acoustic disturbances, no noise bursts could be detected. However, the impulsive noise was still observed in free-fall experiments, and a ranging system was built to determine the location of these noise bursts with respect to a fixed point. All signals originate close to a curve that seems to reproduce the trajectory of the sphere showing that the noise is produced either on the surface of the sphere or in its wake at nearly a constant distance from the sphere. The bursts were observed to occur in groups and calculation of the Strouhal number based on the average speed of the sphere and the time interval between group of bursts yielded a value close to that for a nonaccelerated sphere at comparable Reynolds number. This could mean that the noise is produced either by the separation bubble (which fluctuates at a rate equal to the vortex shedding frequency) or by the separated vortex in the wake of the sphere.

Thesis  
Directed:

T. Kunze, "Experimental Studies of  
Impulsive Noise Produced by Spheres  
Moving through Water," Master's Thesis,  
March 1980.

**Title:** Transmission of Acoustic Energy from a Fluid Wedge into a Fast Bottom

**Investigators:** James V. Sanders and Alan B. Coppens,  
Associate Professors of Physics and Chemistry

**Sponsor:** Office of Naval Research

**Objective:** To develop the ability to predict the properties of a sonic beam transmitted into a fast bottom underlying a wedgeshaped fluid-like layer.

**Summary:** This is a continuation of an ongoing project. Since the summary presented in last year's activity report, the computer analysis has provided beam predictions over a selection of values of densities, speeds of sound, and wedge angles for both finite-distance and infinite-distance sources. The results have revealed the importance of phase coherent interference between adjacent beams in the bottom. The programs have been adapted to allow for losses in the bottom. Empirical expressions for the angle of depression and the beam width of the first beam (resulting from the cutoff of the lowest normal mode) have been obtained; the expressions are simple functions of the ratio of densities, ratio of speeds of sound, wedge angle, and critical angle. The problem has also been reapproached from the theoretical side using the method of stationary phase to isolate the principle contribution of each image to the field at some point in the bottom. This has revealed the importance of diffraction effects, which will be studied this coming year, but also, and most importantly, allowed the problem to be programmed for a moderate sized table top calculator (Wang 2200) with a running time on the order of 5 minutes. The new approach has also provided considerable physical understanding of the nature of the propagation which was not available from the older "brute force" approach.

Publication: A. B. Coppens, J. V. Sanders, N. Bradshaw,  
M. Kawamura, and I. Ioannou, "Propagation  
of Sound from Water into a Sloping Fast  
Bottom," Journal of the Acoustical Society  
of America, Suppl. 1, Vol. 66, Fall 1979.

Conference  
Presentation: "Propagation of Sound from Water into a  
Sloping Fast Bottom," 98th Meeting:  
Acoustical Society of America, Salt  
Lake City, Utah, 26-30 November 1979.

Thesis  
Directed: N. Bradshaw, "Propagation of Sound in a  
Fast Bottom Underlying a Wedge-Shaped  
Medium," Master's Thesis, September 1980.

**Title:** Aerosols in the Marine Boundary Layer, Optical Extinction Effects

**Investigators:** Gordon E. Schacher, Associate Professor of Physics and Chemistry, and Kenneth L. Davidson, Associate Professor of Meteorology.

**Sponsor:** Naval Ocean Systems Center

**Objective:** Perform at sea experiments to assess the use of aerosol counters to predict optical extinction. Verify the NPS model for predicting the boundary layer aerosol distribution. Use the results of past experiments to assess equilibrium aerosol model predictions.

**Summary:** A major at sea experiment, Marine Aerosol Generation and Transport (MAGAT) was performed in April 1980. The experiment utilized the ship RV/ACANIA, the Airborne Research Associates aircraft, and the Monterey Bay optical range. Shipboard aerosol measurements have been used to calculate near surface optical extinction. These calculated values have been compared to those measured directly on the optical range. The results were very good confirming the validity of calculated extinctions. Initial evaluation of the aircraft results show that the aerosol dry radius number density is a well mixed parameter, which confirms one of the crucial assumptions of the NPS model. Completion of data analysis to fully verify the model is underway. Results from the JASIN and CEWCOM-78 experiments show that the Katz-Munn Ruhnke equilibrium model performs very well except for an incorrect estimation of the continental component.

**Publications:**

K. L. Davidson, G. E. Schacher, C. W. Fairall, D. E. Spiel, E. C. Crittenden, and E. A. Milne, "Verification of the Bulk Model for Calculations of the Overwater Index of Refraction Structure Function,  $C^2$ ," NPS Technical Report, NPS61-80-016, July 1980.

G. E. Schacher, K. L. Davidson, and C. W. Fairall, "Optical Aerosol Spectrometers, Factors Affecting Optical Extinction Predictions," NPS Technical Report, NPS61-80-013, April 1980.

Title: Overwater Transport and Dispersion

Investigators: Gordon E. Schacher, Associate Professor of Physics and Chemistry, and Kenneth L. Davidson, Associate Professor of Meteorology.

Sponsor: Bureau of Land Management

Objective: Determine the characteristics of transport in the marine atmospheric boundary layer in order to parameterize air pollution models.

Summary: During September 1980, an overwater tracer experiment in the Santa Barbara Channel was performed. NPS determined the properties of the marine boundary layer and released SF<sub>6</sub> tracer gas from the RV/ACANIA. Configuration of the plume was determined by analyzers at fixed points on the shore and mobile units in an aircraft, a van, and a small boat. A second experiment will be performed in January 1981 to determine transport in the winter. Data analysis will follow completion of the second experiment.

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A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH PROGRAM, (U)      F/G 5/2  
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**Title:** Surface Truth Verification and Investigation of Stability and Wind-Wave Interaction Effects on the SEASAT Scatterometer

**Investigators:** Gordon E. Schacher, Associate Professor of Physics and Chemistry, and Kenneth L. Davidson, Associate Professor of Meteorology.

**Sponsors:** National Aeronautics and Space Administration  
National Oceanic and Atmospheric Administration

**Objectives:** There are two objectives. The first is to assess the performance of the finalized SASS algorithm on an independent data set. The second is to determine the effects of atmospheric hydrostatic stability and the interaction of the waves with the momentum transfer.

**Summary:** Comparisons are to be made between wind velocity measured on shipboard and winds derived from SEASAT satellite measured backscatter. Concurrent data is available for the JASIN and MABLE-WC experiments. All shipboard data has been evaluated. Completion of the project awaits reception of the satellite data from Jet Propulsion Laboratory.

**Publication:** K. L. Davidson, G. E. Schacher, C. W. Fairall and J. Jarrell, "Observational Results Pertaining to Scatterometer Interpretations," Proceedings of the Oceanography from Space Conference, Venice, Italy, April 1980.

Title: Impurities in Tokamaks

Investigators: F. Schwirzke, Associate Professor of Physics and Chemistry, and R. J. Taylor, Center for Plasma Physics and Fusion Engineering, University of California, Los Angeles

Sponsor: Department of Energy

Objective: In this project methods of impurity control are studied and diagnostics are developed.

Summary: Impurities released by plasma-surface interactions play a major role in influencing the performance characteristics of many of today's magnetic fusion machines, especially tokamaks. Loosely bound metal atoms are probably contributing to the observed, higher than expected, high-Z impurity concentrations in tokamaks. Knowledge of the surface conditions during tokamak discharges is most important for a better understanding of processes related to plasma-surface interactions, discharge cleaning, and impurity transport.

Conventional surface analytic techniques like auger spectroscopy, SEM and energy electron diffraction have been used to measure after many discharges the integrated accumulation of impurities on titanium coated surfaces.

Publications:

R. J. Taylor, R. F. Bunshah, and F. Schwirzke, "Impurity Control of Tokamaks with In Situ Metal Deposition," J. of Nuclear Materials, 94 & 95, 1980, 5 pages.

R. J. Taylor, P. Lee, N. C. Luhmann, Jr., A. Mase, G. J. Morales, W. A. Peebles, A. Semet, F. Schwirzke, S. Talmadge, S. J. Swenberg, M. A. Hedenmann, B. S. Levine, R. W. Gould, "ICRF Heating and Particle Transport in Tokamaks," Nuclear Fusion Supplement, 8th Conference Proceedings, Brussels, 1980.

F. Schwirzke, and R. J. Taylor, "LISA, Laser Induced Surface Analysis," Proceedings of the Workshop on New Diagnostic Related to Impurity Release (CONF - 790585), DoE, October 1979, pp. 13.1 - 13.14.

Conference

Presentations:

F. Schwirzke, and R. J. Taylor, "In Situ Deposition of Titanium Coatings," Workshop on Tokamak Impurity Control, DoE, Germantown, MD, 20-21 February 1980.

R. J. Taylor, R. F. Bunshah, and F. Schwirzke, "Impurity Control of Tokamaks with In Situ Metal Deposition," paper F9 presented by F. Schwirzke at the 4th International Conference on Plasma Surface Interactions in Controlled Fusion Devices, Garmisch-Partenkirchen, Germany, 21-25.

F. Schwirzke, and R. J. Taylor, "Surface Damage by Sheath Effects and Unipolar Arcs," paper N2 presented by F. Schwirzke at the 4th International Conference on Plasma Surface Interactions in Controlled Fusion Devices, Garmisch-Partenkirchen, Germany, 21-25 April 1980.

R. J. Taylor, F. Schwirzke, et al., "ICRF Heating and Particle Transport in Tokamaks," paper IAEA-CN-38/D2 presented at 8th International Conference on Plasma Physics and Controlled Nuclear Fusion Research, Brussels, 1-10 July 1980.

Title: Plasma Surface Interaction

Investigator: Fred Schwirzke, Associate Professor, Department of Physics and Chemistry

Sponsor: NPS Foundation Research Program

Objective: To investigate unipolar arc damage of several materials, including stainless steel and TiC.

Summary: Plasma surface effects are of importance during the operation of high power plasma facilities like beam weapons, some high power lasers, high power x-ray generators, high power switches and controlled thermonuclear fusion devices, when material surfaces are exposed to particle and photon fluxes from a hot plasma. Such exposure causes surface damage via physical and chemical sputtering, evaporation and unipolar arcing. The last one, arcing, represents one of the most damaging plasma surface interaction processes. Arc craters produced by plasma surface contact were detected with the scanning electron microscope on a stainless steel surface which was exposed to the plasma produced by a Q-switched laser pulse. The laser produced plasma with an electron temperature of about 100 eV expands rapidly from the focal spot on the target surface in normal and in radial direction. Although no external voltage is applied, about 20,000 unipolar arc craters are observable on the stainless steel surface which was exposed to the radially expanding plasma for the short time of a few hundred nanoseconds. The size of the arc craters becomes smaller with increasing distance from the focal spot. This evidence shows that a laser produced plasma can be used to study plasma surface effects.

Publications: F. Schwirzke and R. J. Taylor, "Surface Damage by Sheath Effects and Unipolar Arcs," Journal of Nuclear Materials, 94 and 95, (1980).

F. Schwirzke, "Arcing, an Experimental Investigation of Plasma Surface Interaction," Bull. Am. Phys. Soc., 24, 971 (1979).

Conference

Presentations:

F. Schwirzke, "Arcing, an Experimental Investigation of Plasma Surface Interaction," 21st Annual Meeting of the Division of Plasma Physics of the American Physical Society, Boston, MA, 12-16 November 1979.

F. Schwirzke and R. J. Taylor, "Surface Damage by Sheath Effects and Unipolar Arcs," 4th International Conference on Plasma Surface Interactions in Controlled Fusion Devices, Garmisch-Partenkirchen, Germany, 21-25 April 1980.

F. Schwirzke, D. J. Armstrong and J. H. Cowcitch, "Generation of Acoustic Pulses in Water by Laser Induced Breakdown," 1980 IEEE International Conference on Plasma Science, 19-21 May, 1980. Conference Record - Abstract, IEEE Catalog No. 80CH1544-6 NPS, p. 65 (1980).

Theses

Directed:

M. T. Kelville and R. W. Lautrup, "An Investigation of Unipolar Arcing Damage on Stainless Steel and Titanium Carbide Coated Surfaces," Master's Thesis, June 1980.

J. H. Barker, III, and R. J. Rush, "Plasma Surface Interactions," Master's Thesis, December 1980.

Title: Study of Basic Mechanisms that Lead to Arcing

Investigators: F. Schwirzke, Associate Professor of Physics  
and Chemistry, and O. Biblarz, Associate  
Professor of Aeronautics.

Sponsors: Air Force Weapons Laboratory

Objective: To investigate plasma surface interactions  
and the onset of arcing as a function of  
plasma parameters for several materials of  
interest to the AFWL electrical laser pro-  
gram.

Summary: Electrical discharge lasers have the capabi-  
lity of delivering large laser outputs which  
can be pulsed controlled. Arcing severely  
limits performance, however, even in the  
highly scalable ionizerosustainer glow dis-  
charges. We study the basic mechanisms that  
lead to arcing and develop a discharge model  
which will aid the prediction of arcing  
conditions. This work is both analytical and  
experimental and is directly related to the  
AFWL electric laser program. It is recognized  
at the present that arcing may be caused by  
a variety of conditions which do not necessari-  
ly exist simultaneously and thus it becomes  
necessary to focus attention on a specific  
device.

Work began in July 1980.

**Title:** Range Studies Program

**Investigators:** O. B. Wilson, Jr., Professor of Physics and Chemistry, and G. L. Sackman, Associate Professor of Electrical Engineering.

**Sponsor:** Naval Undersea Warfare Engineering Station

**Objective:** To continue the study of the long-term requirements and plans of the Naval Undersea Warfare Engineering Station in areas of ship and underwater weapons testing, and, based on changing technology and changing operational needs of the Navy, recommend changes on upgrading or replacing equipment, modifications of procedures and development of new testing concepts.

**Summary:** About eight faculty members from various disciplines and a number of officer-students participated in various task projects. Individual summaries are reported elsewhere in this document.

The investigators serve as coordinators for this program and as individual investigators. The program task titles for this reporting period include: Kalman Filtering Applications; Improvements in Accuracy Tests for Sonar and Weapons Systems; Electromagnetic Wave Propagation Studies; Acoustic Imaging in Sediment; Torpedo Path Estimation; Fiber Optic Applications in Underwater Range Application; Surface Interference Effects on Underwater Acoustic Measurements; Experiments on AntiReflection Coatings; SFSK Coding Methods.

**Publications:** O. B. Wilson, Jr., "Annual Summary Report of Range Studies Program," NPS-61-81-001 PR, October 1980".

**Title:** Underwater Acoustic Noise Due to Surf Phenomena

**Investigators:** O. B. Wilson, Jr., Professor of Physics and Chemistry, Stephen N. Wolf and Frank Ingognito, Naval Research Laboratory

**Sponsor:** NPS Foundation Research Program and Naval Sea Systems Command

**Objective:** To determine whether surf generated noise is a significant component of the shallow water ambient noise.

**Summary:** Horizontal directionality of ambient noise was measured at ranges up to 4 km from the eastern shore of Monterey Bay, California. Water depths at the sites ranged from 8 to 73 m. A steerable cardioid receiving pattern was formed using signals telemetered from dipole and omnidirectional hydrophones suspended from tethered buoys. With no nearby shipping, whenever the maximum of the cardioid pattern was directed toward the beach, noise levels in the range 20 to 500 Hz were greater than those obtained when the maximum was directed seaward. This difference (seaward vs. shoreward), which depended on range from the beach and on frequency, was 7 dB at 100 Hz at the 4 km site. Surf beat was clearly audible when the cardioid maximum was steered shoreward at ranges as great as 2 km. The measurements, made when wind and surf were high, suggest strongly that under some conditions breaking surf can contribute significantly to ambient noise in fairly deep continental shelf waters.

**Publications:** A manuscript is in preparation and will be submitted to the Journal of the Acoustical Society of America.

**Conference Presentations:** The results will be reported in the Fall 1980 meeting of the Acoustical Society of America.

## DEPARTMENT OF ELECTRICAL ENGINEERING

The Research Program of the Electrical Engineering Department covers the following areas: Electronic Warfare Systems; Electromagnetics, Antennas and Microwaves; Communications; Signal Processing; Range Studies; Digital Systems; Control Systems; Command, Control and Communications (C<sup>3</sup>) and Aircraft Engine Emissions. Projects in these areas generally involve one or more faculty members working with several thesis students.

### ELECTRONIC WARFARE SYSTEMS (EW)

The effect of Soviet Airborne Jammers on target detection characteristics of U.S. Navy radars was a project completed by Professor David Hoisington. The detection characteristics of various Navy radars in a jamming environment were analyzed as functions of aircraft and missile range and of target direction with respect to a task-force center.

Professor Lonnie Wilson continued his work on automated target classification. Several ship classification system architectures have been analyzed and preliminary analyses made. Professor Wilson also initiated a project on Multi-Source Track Management (MSTM) which has as its goal provision of theoretical analysis and system trade off analysis for the MSTM function of the Advanced Combat Direction System. The program aims to develop advanced NTDS concepts for the 1990's in the U.S. Navy.

A program to analyze the effect of various electronic countermeasures (ECM) against the AEGIS missile system was initiated by Professor Harold Titus. A simulation was conducted on ECM against the SM-2 and an adaptive tracking algorithm for the SPY-1 radar in an ECM environment is being evaluated against an ECM environment. Recent efforts concerned simulations of the effectiveness of ECM and tactics against possible threat missiles.

### ELECTROMAGNETICS, ANTENNAS AND MICROWAVES

Professor O. M. Baycura initiated a project for characterization and suppression of radio frequency emissions from microcomputers. Results are presently being compared with government standards.

An effort to determine if shipboard cryogenic antennas are feasible to allow ship-to-submarine EM communications is the subject of a project by Professor Stephen Jauregui, Jr. Results indicate that such antennas are not yet practical for shipboard use. Professor Jauregui also conducted the following

five projects: (1) Marine mobile tactical antenna modeling. Various whip jeep and trailer configurations were modeled with the NEC program; (2) Narrowband and wide aperture HFDF antenna capability against short duration signals. Data was taken and analyzed for usefulness in tactical applications; (3) Operational HF multicouplers. Various wideband multi-couplers were tested using new measurement techniques; (4) Simulation of the AN/URD-10 and AN/SRD-19 mast mounted VHFDF antenna systems. The NEC antenna simulation program was run for various parameters of the antennas to determine basic patterns; and (5) Shipboard noise and interference measurements. Visits were made to five submarines and one surface ship with data taken in port and underway. Data were then analyzed.

Professor Jeffrey Knorr continued his project on transmission media for millimeter wave integrated circuits. The focus has been on theoretical and experimental studies of millimeter wave fin-lines and fin-line discontinuities. Work on various aspects of the problem is nearing completion.

Radar target identification via time-domain scattering signatures is an ongoing project of Professor Michael Morgan. A new theoretical concept for calculations has been formulated and successfully applied to the basic problem of wire scattering. Finite element numerical methods are used. Development of a time-domain laboratory was initiated based on a scale model representation. Professor Morgan also initiated a project on recovery of cross-polarized channels in antenna sidelobes with the objective of investigating algorithms to decouple cross-polarized channels. Computer modelling is being used as a test procedure.

Professors Kenneth Gray and Morgan continued work on their study of SM-2 EMP from nuclear detonation. Computer analysis of voltage responses at various output channels of the seeker antenna was done. Also accomplished was computation of induced current levels on the missile body. Professors Gray and John E. Ohlson continued their project on shipboard microwave radio frequency interference (RFI). Instrumentation to measure RFI aboard ships has been constructed. Measurement and characterization of the RFI environment has been completed.

A magnetic monitoring station was established at Chews Ridge, CA as part of a project initiated by Professors Paul H. Moose and Otto Heinz (Physics & Chemistry). The objective is to develop long-term background data, to provide a reference site for correlation with ocean floor measurements and to study propagation of phenomena of magnetospheric micro-pulsations. A cost-free site was located and superconducting SQUID magnetic gradiometers obtained. Periodic experimentation will commence when all equipments are operational.

## SIGNAL PROCESSING

Professor Jauregui initiated a project on automatic voice exploitation. The objective is to develop a technique for automatic tactical exploitation of voice signals. State-of-the-art work on tactical voice recognition (language and key-word or phrase) is planned as well as the development of a microprocessor based language recognition device.

Discrete signal processing studies were continued by Professor Sydney Parker. A number of significant results have been achieved in parametric system modeling, adaptive signal processing and signal processing applications in various other areas. Professor Parker has an ongoing project on reduced order characterization of circuits and systems. It has been determined that a transitional type of formulation allows a full set of model parameters to be obtained readily from measured data. A generalized discrete nonlinear model has been postulated and tested. Conditions for identifiability of systems in terms of model parameters have been derived. A unified approach has been provided for both linear/nonlinear parameteric modeling.

Professor John Powers continued work on his projects on computer-aided acoustical imaging and techniques of acousto-optical RF signal analysis. Data acquisition and image display methods were improved and design begun on a microcomputer system to control detector scan and data collection. For the second project, filtering and recovery of signals by hetro-dyne detection has been demonstrated. Excising element diffraction and various excision elements were investigated.

An ongoing project by Professor George Sackman concerns development of an acoustic imaging system for use in torpedo recovery. Preliminary calculations have been made and experimental tests conducted using a side-scan sonar and sub-bottom profiler. Also, computer simulation of a digital beam former has been done. Professor Sackman initiated a project on trace function beam former for a circular array. The objective is an experimental verification of a previously developed theory of a technique to provide good bearing accuracy with an array diameter smaller than a wavelength.

## COMMUNICATIONS

Professor Glen Myers initiated a project on FSK (Frequency Shift Key) coding methods. The objective is a selection of four "good" binary code words to be used as radio receiver addresses. Effects of code word errors and random bits were derived and error correcting codes were determined.

The SATCOM signal analyzer, directed by Professor John Ohlson, continues to be productive. A prototype signal analyzer was constructed and tested. The analyzer will be modified to permit monitoring of demand assignment/multiple access (DAMA) signals. Additionally, Professor Ohlson initiated a project on a jammer analysis and monitoring subsystem (JAMS) with the objective of designing and building a feasibility model of a monitoring system for characterizing users and jammers of the DSCS III satellite system.

#### RANGE STUDIES

Ongoing work on fiber optics in underwater range applications is being done by Professor Powers. Candidate fiber optic cables have been identified and engineering design analysis done. An integrated Circuit signal simulator and a microprocessor controlled simulator have been implemented. PCM and analog links are being designed and will be tested.

Professor Knorr continued his work on propagation loss for several line-of-sight paths in the Pacific Northwest. A radio propagation data acquisition system has been installed. Data is being acquired and analyzed.

#### DIGITAL SYSTEMS

Professor Tien Tao continued a project on development of focal plane processing techniques for surveillance system applications. Focal plane processing techniques used on five space programs have been examined. A hierarchical bus communication multiple microcomputer system is being developed. New image processing algorithms have been developed for clutter suppression and for target acquisition. Additionally, Professor Tao initiated a program to investigate and develop concepts, approaches and skills to enhance the computing power of sixteen-bit microcomputers by microcomputer compatible array processors with a long range goal of using the combination of microcomputer and array processor in a multiple microcomputer system. A benchmark test program image processing problem has been developed and two 16-bit microcomputers and compatible array processors selected. Execution time results were obtained.

An ongoing project by Professors Mitchell Cotton, Rudolf Panholzer and Uno Kodres (Computer Science) continues to look at multi-computer methods for large-scale problem (AEGIS) using Intel sixteen (16) bit micro-processors. Specific applications are on a radar signal processing module and a beam steering module.

## CONTROL SYSTEMS

Professors Alex Gerba and George Thaler continued work on their project on a sequential steering algorithm for the Project Courageous Program. A newly developed graphics computer program using the Vector Graphics Terminal in the computer laboratory shows great promise for providing an improved control systems design.

A project on control systems design studies was initiated by Professor Robert Strum and Donald Kirk. The objective is to investigate the utility of modern control theory in solving strategic missile control problems. An adaptive notch filter design has considerably improved missile response to bending modes. This design will be refined and a feasibility study made for micro-processor implementation of an adaptive algorithm.

## COMMAND, CONTROL AND COMMUNICATION ( $C^3$ )

Professor Moose initiated a project on research in communications, command, control and intelligence ( $C^3I$ ). The objective is to develop a dynamic model for  $C^3I$  information. The model has been proposed and its sensitivity and stability are being studied.

The ongoing work of Professor John Wozencraft involves battle assessment for  $C^3$ . Efforts to date consist of meetings and literature searches to define the nature of the problem and learn of past approaches.

## AIRCRAFT ENGINE EMISSIONS

Professor John Duffin worked on an ongoing project for revision of an aircraft engine emissions catalog. All engine emissions data available was reviewed and a format of data to be included in a summary catalog was proposed.

Title: Characterization and Suppression of Radio-Frequency Emissions from the TRS-80 Micro-computer

Investigator: O. M. Baycura, Associate Professor of Electrical Engineering

Sponsor: Naval Air Systems Command

Objective: To find the radio frequencies emitted by a TRS-80 microcomputer and find a means to suppress the radiations below the standard emission levels.

Summary: The noise radiated by this unit has been measured and is being compared with government standards.

Thesis  
Directed: Djoko Achyanto and Christopher Hollands,  
"Digital System Electromagnetic Interference Study," Master's Thesis, December 1980

**Title:** Revision of the "Aircraft Engine Emissions Catalog"

**Investigators:** J. H. Duffin, Professor of Electrical Engineering

**Sponsor:** Aircraft Environmental Support Office

**Objective:** To review data on aircraft engine emissions collected by AESO and others; correlate engine types which may be grouped together on the basis of specifications review AESO method for interpreting data; develop computer programs for analysis and storage of data suggest formats to make catalog more useful and apply error analysis to data as needed.

**Summary:** All engine emission data available was reviewed. Methods of presenting the data in a condensed and meaningful fashion was proposed. Correlations based on engine types were proposed. Issuance of a Summary Catalog awaits review and correction of original data taken by Dr. J. A. Krimomel.

**Publication:** Catalog itself (when issued)

Title: NPS Sequential Steering Algorithm, Project Courageous Program

Investigators: Alex Gerba, Jr., Associate Professor of Electrical Engineering, and George Thaler Distinguished Professor of Electrical Engineering

Sponsor: Naval Underwater Systems Center

Objective: A continuing program to design and develop advanced torpedo control schemes which successfully optimize the steering performance for Project Courageous.

Summary: This classified project was first funded at NPS in quarter III of 1980 and as a result of the outstanding work of thesis student Jacobs, it has become fully productive with results that currently outpace those of private contractors who have worked on this project over a 3 year period.

New thesis students and newly developed graphics computer programming of the Vector Graphics Terminal in the Computer Laboratory shows great promise for a technical breakthrough as eagerly awaited by the project office. A demonstration of this potential was presented at the November 1980 visit by the Sponsor, and a new design scheme will be presented at the February 1981 update to the Sponsor.

Publications: Letter Report, "Sequential Mode, Filter Compensated Controller Design for Event Edge Following: A Brief Summary of Research Progress and Goals," October 1980. This report written in response to sponsor request and was used in their semi-annual Management Review of the project.

Thesis  
Directed: R. W. Jacobs, "An Investigation of a Non-Linear Control Problem in Three Coupled Dimensions," Electrical Engineer's Thesis, June 1980.

**Title:** Effect of Soviet Airborne Jammers on Target-Detection Characteristics of U.S. Navy Radars

**Investigator:** D. B. Hoisington, Professor of Electrical Engineering

**Objective:** To analyze the ability of U.S. Navy surface and airborne radars to detect Soviet aircraft and missiles in the presence of massive jamming.

**Summary:** In the scenario studied a two-carrier task force is approaching Soviet-held territory. The Soviets launch a massive airborne attack on a wide front employing land-based aircraft and air-to-surface missiles. The aircraft and the missiles are protected by massive jamming generated by all attack aircraft as well as by stand-off jammers.

The detection characteristics of the various Navy radars in this jamming environment is analyzed as a function of aircraft and missile range, and of the direction of the target with respect to task-force center.

Title: Automatic Voice Exploitation

Investigator: S. Jauregui, Associate Professor of Electrical Engineering

Sponsor: Naval Electronics Systems Command

Objective: To develop a technique for automatic tactical exploitation of voice signals

Summary: This period of research covers the initial work of determining the state-of-the-art feasibility of doing exploitation of tactical voice recognition - both in language recognition and in key word or phrase identification. Follow-on work will be done to develop a microprocessor based system to recognize which language is being spoken and to determine if certain keywords or phrases are being used by an arbitrary voice.

Thesis  
Directed: K. Kolarcik, "Feasibility and Applicability of Tactical COMINT Without Linguists,"  
Master's Thesis, December 1979.

Title: Cryogenic Antennas for Shipboard Use

Investigator: S. Jauregui, Associate Professor of Electrical Engineering

Sponsor: Naval Ocean Systems Center

Objective: To determine if shipboard cryogenic antennas are feasible to allow ship-to-submarine EM communications.

Summary: The practical state-of-the-art in cryogenics, cryogenic cables and small antennas was investigated. The results indicated that such antennas are not yet practical for shipboard antennas.

Thesis  
Directed: J. Kolman, "A Review of Cryogenic Antenna Principles and Their Application to US Navy Requirements for Small Low Profile High Efficiency Low Cost Antenna Systems,"  
Master's Thesis, June 1980.

Title: Marine Mobile Tactical Antenna Modeling

Investigator: S. Jauregui, Associate Professor of Electrical Engineering

Sponsor: Naval Ocean Systems Center

Objective: To determine radiation patterns of mobile omni antennas over a variety of grounds and with a variety of trailers and vehicles.

Summary: A variety of whip, jeep, trailer configurations were modeled with the NEC program at a variety of frequencies and ground conditions. The effects on power output, efficiency, and uniformity of radiation pattern were tabulated. A thesis report will be in December 1980.

**Title:** Narrowband and Wide Aperture HFDF Antenna Capability Against Short Duration Signals

**Investigator:** S. Jauregui, Associate Professor of Electrical Engineering

**Sponsor:** Naval Electronics Systems Command

**Objective:** To determine the effects of short duration signals on HFDF accuracy for both a narrow aperture mast mounted array and for a wide aperture deck mounted array.

**Summary:** Actual data was taken from both a mast mounted narrow aperture coaxial spaced loop antenna and from the outboard deck edge ferrite loaded loop array. These data were then divided into equivalent short samples and analyzed for usefulness in tactical applications. The deck edge array was entirely tasked against ground wave while the mast mounted array data was sky-wave.

**Theses Directed:**

D. Russell, "The Effects of Short Duration Signals on the Accuracy of the Shipboard HFDF System," Master's Thesis, June 1980

D. Sheppard, "Radio Direction Finding on High Frequency Short Duration Signals," Master's Thesis, June 1980.

Title: Operational HF Multicoupler Investigation

Investigator: S. Jauregui, Associate Professor of Electrical Engineering

Sponsor: Naval Electronics Systems Command

Objective: To determine methods of measuring specification on HF multicouplers, emphasizing the use of wide band noise.

Summary: Various wideband multicouplers were tested using both the standard two tone test and a newly developed procedure using the Marconi 0A1090B White noise test set. A first cut at new measurement techniques was made which avoids the pitfalls of the two tone narrow-band dynamic range techniques currently in use.

Thesis  
Directed: D. Smith, "Intermodulation Product Susceptibility Testing of Multicouplers Using White Noise," Master's Thesis, September 1980.

**Title:** Shipboard Noise and Interference Measurements

**Investigators:** S. Jauregui, W. Vincent, Associate Professor's of Electrical Engineering

**Sponsor:** Naval Electronics Systems Command

**Objective:** To determine types of self generated noise, interference and intermodulation products and their effect on various ESM and DF systems.

**Summary:** Visits were made to five submarines and one surface ship. Data were taken both in port and underway. These data were then analyzed as to their effect on ESM/DF systems. The report will be completed in December 1980.

Title: Simulation of the AN/URD-10 and AN/SRD-19  
Mastmounted VHFDF Antenna Systems

Investigator: S. Jauregui, Associate Professor of  
Electrical Engineering

Sponsor: Naval Electronics System Command

Objective:

1. Using a computer simulation on the An/  
SRD-19 VHFDF antenna determine the effects  
of TACAN and other nearby structures on  
DF accuracy.
2. Simulate the antenna patterns of the An/  
URD-10 prototype antenna.

Summary: The NEC antenna simulation program was run  
for a variety of frequencies and elevation  
angles for both the URD-10 and the SRD-19  
to determine basic patterns. Since the  
URD-10 is a prototype this was all that was  
done on it. The SRD-19 antenna was then  
modeled as mounted on the ship both with  
and without TACAN. A thesis report on the  
SRD-19 work will be out in December 1980.

Publications: S. Jauregui and R. Adler, "URD-10 Antenna  
Study," NPS Technical Report, NPS62-80-009  
PR, May 1980.

**Title:** Communications System Studies

**Investigator:** Jeffrey B. Knorr, Associate Professor of Electrical Engineering

**Sponsor:** Naval Undersea Warfare Engineering Station

**Objective:** To determine the propagation loss for several line-of-sight radio paths in the Pacific Northwest, including the effects of multi-path and fading.

**Summary:** A Radiowave Propagation Data Acquisition System has been installed. Data is being acquired and analyzed.

**Publications:**

J. B. Knorr, "A Radiowave Propagation Data Acquisition System," NPS Technical Report, NPS62-79-001, October 1978.

J. B. Knorr, "A Dual Channel Radiowave Propagation Data Acquisition and Transmission System," NPS Technical Report, NPS62-79-010 PR, September 1979.

**Theses  
Directed:**

P. Ruputz, "Remote Acquisition of Atmospherically Propagated Radio Frequency Communication Channel Performance Data by Way of Dial-up Telephone Networks," Master's Thesis, June 1979.

J. Cano, "The Statistics of Multipath Fading for an Overwater Path at VHF Applied to Communications Links at NUWES Keyport, Washington," Master's Thesis, June 1979.

Title: Millimeter Wave Transmission Media

Investigator: J. B. Knorr, Associate Professor, Electrical Engineering Department

Sponsor: NPS Foundation Research Program

Objective: The objective of this research is to study transmission media for millimeter wave integrated circuits and to obtain solutions to unsolved problems in the areas of wave propagation, discontinuities circuits and components.

Summary: The progression of electronic technology to the present time has permitted the realization of electronic systems utilizing the electromagnetic spectrum up to about 40 GHz. Utilization is heavy through 12 GHz and decreases to sparse between 12 GHz and 40 GHz. Parallel developments at "optical" frequencies have led to utilization of the spectrum above 300 GHz. Here utilization is heavy near the visible portion of the spectrum ( $\lambda = 1 \text{ um}$  or  $f = 300 \text{ THz}$ ) and decreases rapidly below this frequency. There thus exists a gap in the utilization of the electromagnetic spectrum the millimeter wave region from 40 - 300 GHz.

It has become clear that there are certain military requirements that can be uniquely satisfied by systems operating in the 40-300 GHz millimeter wave band. Millimeter wave systems which are currently being investigated to satisfy the requirements include missile seekers, radar, mapping, communications and electronic warfare. In this band, however, the realization of practical systems awaits the solution of some basic problems.

One of the major impediments to the realization of millimeter wave systems is the lack of devices and components for use in the band. Devices and components which are available are costly and offer only limited performance. At microwave frequencies, waveguide and printed lines such as microstrip and slotline have been proven optimum for the realization of components, devices and integrated circuits. At optical frequencies, dielectric fibers have been developed to very high quality and dielectric integrated optical circuits are being pursued.

The identification of optimum transmission media for millimeter wave applications is an area of current interest. Various structures must be studied and compared with particular attention being given to those suitable for mass production. This will then allow the development of high quality components and devices at a reasonable cost.

The Millimeter Wave Transmission Media Project has thus far focused on theoretical and experimental studies of millimeter wave fin-lines and fin-line discontinuities. The emphasis has been directed toward careful comparison of numerical and experimental data and the production of results which are of practical use in design applications. Curves of impedance and wavelength of fin-line have been published for the millimeter wave bands. Work on the representation of a bifurcating septum in fin-line is near completion and several other fin-line discontinuities are currently being investigated. This work will be reported when complete. The results will be useful for the design of various fin-line circuits and components.

Future plans for this continuing project include studies of other transmission structures and discontinuities and investigation of circuit applications of the generated design data.

**Publications:** J. B. Knorr and P. M. Shayda, "Millimeter Wave Fin-Line Characteristics," IEEE Trans. Microwave Theory and Tech., Vol. MTT-28, pp. 737-743, July 1980.

**Theses Directed:** P. M. Shayda, "Spectral Domain Analysis of Fin-Line," Master's Thesis, December 1979

G. Miller, "An Experimental Investigation of Several Fin-Line Discontinuities," Master's Thesis, December 1980

Title: Magnetic Monitoring Station at Chews Ridge

Investigators: P. H. Moose, Associate Professor, Electrical Engineering Department, O. Heinz, Professor of Physics and Chemistry, E. Crittenden, Distinguished Professor of Physics and Chemistry.

Sponsor: NPS Foundation Research Program

Objective: To establish a magnetic monitoring station at Chews Ridge in order to develop long term background data, provide a reference site for correlation with ocean floor measurements and study propagation phenomena of magnetospheric micro-pulsations.

Summary: Choice of a suitable site was pursued early in the year by examination of the available charts, and discussions with geological survey and others familiar with the area. Two aerial reconnaissance flights were made over the Santa Lucia Mountains and the Gabillan range and were followed up by ground expeditions, to check on the line-of-sight radio link possibilities. It was determined that Professor P. C. C. Wang, of the NPS Department of Mathematics, owned property just north and east of the Chews Ridge Forest service lookout. This site was proven by testing and analysis by a Communications Engineer Student to be satisfactorily located for low power VHF radio transmission to Spanagel Hall. Professor Wang kindly offered the use of his property for this work at no charge to the government and it was officially accepted by the Superintendent. Two superconducting SQUID magnetic gradiometers have been located. One has been obtained on indefinite long term loan from Professor George Keller at Colorado State University at Golden. This arrived recently with some evidence of damage in transit. Determination of the extent of damage awaits funding to provide liquid helium for cool down. A second superconducting SQUID magnetic gradiometer has been obtained on a transfer of ownership basis. This magnetometer was purchased by the Navy for a project by Dr. Walter Podney of Physical Dynamics, Inc. La Jolla, CA, for joint work with Scripps

Institute of Oceanography on the magnetic fields generated by internal waves in the ocean. At the completion of that project it was loaned to Autonetics, for a project just completed. It has been returned to the Navy and temporarily moved to NOSC where it awaits transport to Monterey. As the magnetometer is very delicate, the present plan is to transport it to Monterey by Navy truck or on board the Acania when she next stops in San Diego.

Utilization of both magnetometers will require some refurbishing and purchase of liquid helium. As the magnetometers became available just at the end of FY 80 it was not possible to purchase the liquid helium then. Funding support is not being investigated to provide for the costs of refurbishing and operating these two magnetometers.

Both magnetometers that have been obtained are too large, and boil off too much helium to permit their use in submerged containers for ocean bottom measurements at great depths. After a period of gaining experience with these magnetometers, it is planned to design and build, or have built, a magnetometer for ocean bottom use. Containers for retention of the evolved gaseous helium have been located and are available on indefinite long term loan. They are at present located at the Woods Hole Oceanographic Institute.

A one watt VHF half-duplex two-channel telemetry system including a photovoltaic solar panel/battery storage power supply transmitt/receive antennas and a remote receive/control station for location in Spanagel Hall have been ordered from Motorola, Inc. Delivery of this system is expected in early November 1980. Installation will be by separate contract for which additional funds are needed. Frequencies of 138.7 and 143.6 MHz have been assigned by the Navy frequency controller at Point Mugu. Dr. Tony Fraser-Smith from Stanford will be one of the first users of the on-line remote site data. He will be investigating the possibility of

generating a useful prediction of noise activity in the MAD frequency band. The initial sensors at the site will be large coil antennas. Periodic experimentation with the SQUID gradiometers will be undertaken as they become operational.

Thesis  
Directed:

Phillip Beliveau, "Telemetry Design for Solar Powered Geomagnetic Monitoring Station,"  
Master's Thesis, September 1980.

**Title:** Research in Communications, Command, Control and Intelligence

**Investigators:** Paul H. Moose, Associate Professor of Electrical Engineering, J. Wozencraft, Chairman Command, Control, and Communications Group, D. P. Gaver, Professor of Operations Research, and F. Russell Richards, Associate Professor of Operations Research

**Sponsor:** Defense Advanced Research Projects Agency

**Objective:** To develop a dynamic model for C<sup>3</sup>I information that incorporates the effects of counter-C<sup>3</sup> activities and to examine its sensitivity and stability.

**Summary:** The model proposed assumes an inevitable growth of uncertainty inherent in military situations that is only counteracted by continuously importing new information into the system. Counter-C<sup>3</sup> activities are modeled as additional growth terms in uncertainty that depend on the instantaneous knowledge of both sides.

It is shown for this model the relative shift of system equilibrium is directly proportional to the ratio of the counter-C<sup>3</sup> coupling coefficient to the system's natural uncertainty (entropy) growth rate. Furthermore, it is shown that small perturbations from the stable equilibrium are restored to equilibrium by the system forces, i.e., the system is ultrastable. However, a perturbation of entropy of one side, induces a delayed perturbation of entropy on the other side with opposite sign. Thus, if X becomes fortuitously more knowledgeable by chance, Y will in turn, some time later, become more uncertain, and vice versa.

**Title:** Radar Target Identification Via Time-Domain Scattering Signatures

**Investigators:** M. Morgan, Assistant Professor of Electrical Engineering and M. Hamid, Adjunct Professor of Electrical Engineering

**Sponsor:** NPS Foundation Research Program

**Objective:** The long-range goal of this investigation is to establish the feasibility of developing advanced radar systems which are capable of target discrimination and classification via transient time-domain scattering returns. To achieve this objective a comprehensive research program has been established in transient scattering, both from the aspects of analysis-computation and experimental modeling measurements. The thrust of this effort is to extend both the accuracy of time-domain scattering calculations and measurements, as well as to investigate and experimentally implement workable inverse scattering radar target imagery schemes.

**Summary:** A new theoretical concept for calculations of electromagnetic scattering has been formulated by Professor Morgan and successfully applied to the basic problem of wire scattering by LT B. E. Welch in his M. S. thesis. This new formulation partitions the solution of scattering into two interacting operators which can be symbolically represented by a simple feedback network. The work thus far has been performed in the frequency-domain where the forward and feedback operators each reduce to multiport transfer matrices. The power of this method, which uses the finite-element method for the calculation of the forward operator, is in its flexibility to handle complex scattering body geometries, including penetrable media such as "composite" aircraft materials, radomes, and missile plasma exhausts.

The development of the time-domain laboratory commenced during the 1980 Winter Quarter. This work was undertaken by CAPT C.W.

Hammond as his M. S. thesis objective. The laboratory has evolved from a scale model representation to an operational system located in Room 703B of Spanagel Hall. The 36 x 36 foot image plane was welded successfully and no water leaked below throughout the winter season. Two antennas were constructed and are presently being tested and improved using the image plane facility. One of these antennas is a 20 foot wire monopole erected in the center of the image plane in order to transmit a high voltage pulse to the test target. Various test targets were fabricated out of aluminum and were fashioned so as to present symmetric geometrical configurations which can be viewed from different aspect angles. A broadband TEM horn antenna was also constructed and tested for receiving the field scattered from the test target. Beyond this horn the return signal is sent to the digital sampling oscilloscope below the image plane for analysis and display. The scope is linked to a Tektronix 4052 minicomputer which provides software to subtract the incident field from the total field.

**Publications:** M. A. Morgan and B. E. Welch, "The Field Feedback Formulation," National Radio Science Symposium Digest, Boulder, CO, January 1981.

**Theses  
Directed:** B. E. Welch, "Concept Evaluation: Field Feedback Computation of Electromagnetic Scattering," Master's Thesis, June 1980.

C. W. Hammond, "The Development of a Bistatic Electromagnetic Scattering Laboratory Employing Time-Domain Measurement Techniques for Impulse Response Determination and Target Classification," Master's Thesis, December 1980.

Title: Recovery of Cross-Polarized Channels in  
Antenna Sidelobes

Investigator: M. A. Morgan, Assistant Professor of Electrical Engineering

Sponsor: National Security Agency

Objective: Investigation of algorithms to decouple cross-polarized channels in antenna sidelobes.

Summary: Several techniques have been considered to perform the objective. The most versatile method found yet was originally proposed for use in dual polarized transmission links in the presence of rain along the path. This algorithm which incorporates a minimization procedure for a cross-correlation function, is being brought to fruition in this application. Computer modelling of realistic cross-polarization between randomly encoded binary signals is being used as a test of the procedure.

Thesis  
Directed: R. Grant, "Recovery of Cross-Polarized Channels in Antenna Sidelobes," Master's Thesis, December 1980.

**Title:** SM-2 EMP Vulnerability Study

**Investigators:** M. A. Morgan and K. G. Gray, Assistant Professor's of Electrical Engineering

**Sponsor:** Naval Surface Weapons Center

**Objective:** To investigate the vulnerability of the Standard Missile to high electromagnetic pulse (EMP) field strengths generated by nuclear detonations.

**Summary:** Research related to various aspects of the EMP response of the standard missile as performed. This included a computer analysis of voltage responses at the various output channels of the seeker antenna as well as computations of induced current levels on the body of the missile.

Title: SFSK Coding Methods

Investigator: Glen Myers, Associate Professor of Electrical Engineering

Sponsor: Naval Torpedo Station

Objective & Summary: The research concerned the selection of four "good" binary code words to be used as radio receiver addresses. The effects of errors in a code word and of random bits around the code word were derived. A statement on error correcting codes was included.

Publication: Glen Myers, "Selection of Four Good Binary Code Words for Use as Addresses and a Note on Error Correcting Codes With References," NPS Technical Report, NPS62-80-010, April 1980.

**Title:** Jammer Analysis and Monitoring Subsystem (JAMS)

**Investigators:** John E. Ohlson, Professor of Electrical Engineering, and Kenneth Cray, Assistant Professor of Electrical Engineering.

**Sponsor:** Defense Communications Agency and Defense Communications Engineering Center

**Objective:** Design and build a feasibility model of a monitoring system for characterizing users and jammers of the DSCS III Satellite System. This is the beginning of a three year effort.

**Summary:** Assess technical requirements of monitoring system. Predict jammer threat. Evaluate potential hardware. FY81 and 82 will involve design and feasibility model construction.

**Publication:** M. Bar-Tov, K. Gray and J. E. Ohlson, "Satellite Communications Jamming Signals and Their Detection by Acousto-Optic Spectrum Analyzer Techniques," NPS Technical Report, NPS62-80-019TR, 1980.

**Thesis  
Directed:** Mier Bar-Tov, "Satellite Communications," Electrical Engineer's Thesis, August 1980.

Title: SATCOM Signal Analyzer

Investigator: John E. Ohlson, Professor of Electrical Engineering

Sponsor: Naval Electronics Systems Command

Objective: Part of continuing program. Design and construct prototype system to monitor all users and interference passing through Navy communication satellites.

Summary: The prototype SATCOM Signal Analyzer was constructed and successfully tested at NAVCOMMSTA Stockton, CA. Plans for FY81 include modifications to permit monitoring of Demand Assignment/Multiple Access (DAMA) signals.

Publications:

- J. E. Ohlson and C. Musgrave, "Design of the Digital Control and Test Unit Subsystems for a Satellite Signal Analyzer," NPS Technical Report, NPS62-79-014PR, 1979.
- J. E. Ohlson and W. B. Zell, Jr., "Analog-to-Digital Signal Processing in a Prototype SATCOM Signal Analyzer," NPS Technical Report, NPS62-79-015PR, 1979.
- J. E. Ohlson and N. J. Rogers, "Frequency Receivers in the Satellite Communications Signal Analyzer," NPS Technical Report, NPS62-79-016PR, 1979.
- J. E. Ohlson and W. E. Davidson, "Spectrum Receiver and Signal Selection Unit Designs for the Naval Postgraduate School SATCOM Signal Analyzer," NPS Technical Report, NPS62-79-017PR, 1979.
- T. Bruner and J. E. Ohlson, "Software Development for a Satellite Signal Analyzer," NPS Technical Report, NPS62-79-018PR, 1979.
- J. Forgy and J. E. Ohlson, "Long Term Stability and Drift Measurements of Gapfiller's Onboard Oscillator," NPS Technical Report, NPS62-80-001PR, 1980.

J. E. Ohlson and R. M. Thomas, "Implementation of Control Bus Hardware and Utilization of the Naval Postgraduate School Satellite Signal Analyzer," NPS Technical Report, NPS62-80-002PR, 1980.

J. E. Ohlson and R. Mead, "Digital Control and Interfacing for a High Speed Satellite Communications Signal Processor," NPS Technical Report, NPS62-80-003PR, 1980.

J. E. Ohlson and M. J. Langston, "Data Acquisition Unit for SATCOM Signal Analyzer," NPS Technical Report, NPS62-80-004PR, 1980.

J. E. Ohlson and W. Rhoades, "Integration of the Primary Receiver into the Naval Postgraduate School SATCOM Signal Analyzer," NPS Technical Report, NPS62-80-005PR, 1980.

J. E. Ohlson and B. Edgington, "System Development for Satellite Oscillator Stability Measurements," NPS Technical Report, NPS62-80-006PR, 1980.

H. Niemann and J. E. Ohlson, "Touch Panel Software for the SATCOM Signal Analyzer," NPS Technical Report, NPS62-80-012PR, 1980.

D. R. Gamble and J. E. Ohlson, "Signal Selector, Spectrum Receivers and Touch Panel Control for the SATCOM Signal Analyzer," NPS Technical Report, NPS62-80-013, 1980.

L. E. Troffer and J. E. Ohlson, "Development of the Test Unit for the SATCOM Signal Analyzer," NPS Technical Report, NPS62-80-014, 1980.

C. L. Schone and J. E. Ohlson, "Frequency Receiver Development for the SATCOM Signal Analyzer," NPS Technical Report, NPS62-80-015, 1980.

Theses  
Directed:

D. R. Gamble, "Receiver Design and Software Development for the SATCOM Signal Analyzer," Master's Thesis, June 1980.

C. L. Schone, "Frequency Receiver Development for the Satellite Communications Signal Analyzer," Master's Thesis, June 1980.

L. E. Troffer, "The Development of the Test Unit for the SATCOM Signal Analyzer," Master's Thesis, June 1980.

H-J Niemann, "Background Monitor for the SATCOM Signal Analyzer," Master's Thesis, December 1979.

Title: Shipboard Microwave RFI

Investigators: John E. Ohlson, Professor of Electrical Engineering, and Kenneth Gray, Assistant Professor of Electrical Engineering

Sponsor: Naval Electronics Systems Command

Objective: Characterize microwave shipboard RFI which would impact Navy satellite communications.

Summary: Construct instrumentation to measure Radio Frequency Interference (RFI) aboard ships at 7, 20 and 40 GHz. Carry out measurements. Generate characterization of RFI environment. All was completed.

Title: Discrete Signal Processing Studies

Investigator: S. R. Parker, Professor of Electrical Engineering

Sponsor: Naval Electronics Systems Command

Objective: Research is directed toward the development of new algorithms for the processing of discrete signals with applications to system identification, speech, image processing, and radar. This work is particularly significant in light of current developments in VLSI circuit technology which will increase the scope of signal processing possibilities that are feasible for military systems.

Summary: A number of significant results have been achieved during the past fiscal year.

Parametric Modelling of Systems: The problem of obtaining parametric models for linear and nonlinear systems based upon observations of the input and output of the system, is of wide interest with applications ranging from system identification for purposes of performance evaluation and fault detection, to the modelling of speech for bandwidth compression and speech generation. For linear systems, moving average (MA) and autoregressive (AR) models have separately received considerable attention and, based upon Levinson's algorithm, a number of very powerful methods involving lattice filter structures have been developed to obtain model solutions. We have been able to extend these techniques to more general classes of linear and nonlinear models. Based upon an equation error formulation, lattice solution methods, using both batch processing of data and adaptive on-line data processing, have been developed for both signal channel and multi-channel combined autoregressive moving average (ARMA) models. This approach has been extended to include Volterra series models for nonresults have been obtained and indicate that these lattice methods offer substantial advantages over conventional modelling methods. A number of papers presenting these results have been published and distributed, and they

have been discussed with Mr. W. Keiner (Code F105), Naval Surface Weapons Center, Dahlgren, VA who is involved with a Navy wide program on Design for Testability.

**Adaptive Signal Processing:** Adaptive signal processing is of great current interest and is the subject of a forthcoming joint special issue of the IEEE Transactions on Circuits and Systems and IEEE Transactions on Audio Speech and Signal Processing which Professor Parker is co-editor. Such processors or filters adjust their parameters to perform an almost optimal filtering operation without apriori knowledge of input signal statistics. In the case of nonrecursive (FIR) adaptive filters we have studied the use of simplified gradient estimations to reduce the complexity of implementation of the commonly used least mean squared (LMS) algorithm. A thorough analysis of two simplified gradient estimations has been made. The first squared error correction. The analytical results have been confirmed experimentally, and indicate that simplified gradient estimators perform very well and are worth implementing in terms of their reduced complexity. We have also considered the question of the constructing recursive (IIR) adaptive filter algorithms which have the inherent difficulty that the performance surface which is to be searched for the optimal point is multimodel in the feedback parameters and unimodel in the feedforward parameters. This makes the problem of adaptive IIR filter design almost interactable. However, a new approach to IIR adaptive filter design has been developed in which random search is used to adjust the feedforward parameters. Convergence to the globally optimal filter parameters is guaranteed for sufficiently long adaptation time. A convergence time estimation for this algorithm has been derived and is supported by simulation results for an adaptive line enhancer. This approach to adaptive IIR designs has been recommended for a patent application by the ONR patent attorney's office. Other problems which have been studied in the

area of adaptive filters are the use of apriori knowledge of filter structure to improve the random search algorithm and the use of block implementation for data handling. The latter topic deals with the implementation of adaptive filters using blocks of data and is particularly significant in light of array processors which are currently being developed in industry.

Signal Processing Applications: The applications of signal processing techniques to several other areas have been considered in the course of our research. These are contained in the following publication list, the titles of which are descriptive of the contents. Funding for the continuation of this work has been approved.

Publications:

S. R. Parker and U. Ben-Yakov, "A Comparison of Simplified Gradient Estimation for Non-recursive Adaptive Filters," 1980 International Symposium on Circuits and Systems, IEEE Catalog #80CH1564-4. pp 371-374

S. R. Parker, "An Autoregressive Moving Average (ARMA) Discrete Nonlinear Model," 1980 International Symposium on Circuits and Systems, IEEE Catalog #80CH1564-4. pp 918-920.

S. K. Mitra, C. A. Clark and S. R. Parker, "Block Adaptive Filtering," 1980 IEEE International Symposium on Circuits and Systems, IEEE Catalog #80CH1564-4. pp 384-387.

F. A. Perry and S. R. Parker, "Recursive Solutions for Zero-Pole Modeling," Asilomar Conference on Circuits, Systems and Computers, November 1979, IEEE Catalog #79CH1468-8C. pp 509-512.

F. A. Perry and S. R. Parker, "Adaptive Solution of Multichannel Lattice Models for Linear and Nonlinear Systems," 1980 IEEE International Symposium on Circuits and Systems, IEEE Catalog #80CH1564-4. pp 744-747.

S. R. Parker and G. T. Hall, "Computer Modelling of Voice Signals for Adjustable Pitch and Format Frequencies," Asilomar Conference on Circuits Systems and Computers, November 1979, IEEE Catalog #79CH1468-8C. pp 158-161.

"An In-Depth Study of the Sensitivity of Wave Digital Filters," with M. Sanaie-Fard, Asilomar Conference on Circuits, Systems and Computers, April 1979, IEEE Catalog #79CH1468-8C.

"Computer Modelling of Voice Signals for Adjustable Pitch and Format Frequencies," with G. T. Hall, Asilomar Conference on Circuits Systems and Computers, Nov. 1979, IEEE Catalog #79CH1468-8C.

Theses  
Directed:

F. A. Perry, "Parametric Modelling of Linear and Nonlinear Systems," Ph.D Thesis, June 1980.

U. Ben-Yakov, "Efficient Adaptive FIR and IIR Filters," Ph.D Thesis, December 1979.

D. E. Mayaitis, "Comparison of a  $\alpha$ - $\beta$  and Kalman Filter in Track-While-Scan Radars," Master's Thesis, December 1979.

C. Zumrutkaya, "Geometric Design Technique for Two-Dimensional Analog and Digital Filters," Master's Thesis, June 1979.

W. Naiborhu, "Design of FIR Bandpass Filters," Electrical Engineer's Thesis, June 1979.

M. Sanaie-Fard, "An In-Depth Study of Wave Digital Filters," Electrical Engineer's Thesis, June 1979.

T. C. Mor, "A Study of the Stability of Some Two-Dimensional Recursive Digital Filters," Master's Thesis, December 1979.

W. Widada, "Two Dimensional Window Functions," Master's Thesis, December 1979.

Patent  
Application:

U. Ben-Yakov, "Random Gradient Search-IIR Filter," ONR patent disclosure currently under consideration by ONR.

Title: Reduced Order Characterization of Circuits and Systems

Investigator: S. R. Parker, Professor of Electrical Engineering.

Sponsor: Office of Naval Research

Objective: The investigation of techniques for the reduced order modelling of linear and non-linear circuits and systems for purposes of fault detection and performance analysis. The macroscopic model parameters are to be developed dynamically from a finite set of input/output measurements on the circuit/system. The techniques being developed are particularly significant in light of the rapidly developing technology in very large scale integrated circuit technology (VLSI) which can be expected to expand on line computational capabilities well beyond what is available today.

Summary: As a result of research funded this fiscal year, several significant results have been obtained:

1. As a result of linear model studies using an equation error formulation, the coefficients of the denominator of a general zero/pole (ARMA) model have been related to the coefficients of the all pole (AR-autoregressive) model; and the coefficients of the numerator of a general zero/pole model have been related to the all zero (MA-moving average) model coefficients. This transitional type of formulation enables a full set of model parameters, ranging from the all pole model through the mixed zero/pole model to the all zero model, to be obtained readily from measured data.
2. As an extension of the foregoing linear studies, a generalized discrete nonlinear ARMA model has been postulated and tested. This model is based upon the equation error formulation and includes discrete Volterra series expansions for the input and output signals, respectively.

and discrete bivariate expansions between the input and output signals. Minimizing a quadratic equation error between the model and system outputs leads to a model parameter estimation procedure which involves the solution of a set of linear equations. The coefficients of these equations involve high order auto and cross correlation function of the input and output data.

3. The foregoing nonlinear ARMA model is linear in the model parameters and has been shown to be applicable to a broad class of interconnected linear and memoryless nonlinear systems. Conditions for the identifiability of such systems in terms of the model parameters (including a test for the existence of zero delay free loops in the system to be modelled) and memory requirements for the model have been derived.

4. It has been demonstrated that multichannel autoregressive and moving average methods can be applied to the modelling of large scale linear and nonlinear systems from discrete measurements of input and output data. Thus, a multiple-input multiple-output linear system can be modelled efficiently by means of a multichannel autoregressive lattice. A nonlinear Volterra system can be modelled by means of a multichannel moving average lattice; and a nonlinear ARMA system can be modelled by means of a multichannel autoregressive lattice. Solutions to these multichannel lattice model parameters can be calculated by either a batch processing of the measurements, or adaptively on-line. The resulting lattice parameters appear to be a powerful set of descriptors for reduced order identification of linear and nonlinear systems

5. Using an extension of a recently published concept of the regular form of nonlinear kernels for Volterra Series, and the definition of hybrid input signals which can be calculated, the general nonlinear ARMA model has been cast in the form of a

linear multichannel lattice filtering problem. This provides a signal unified approach to both linear and nonlinear parametric modelling which is suitable for either batch or adaptive solution. It includes as special cases the linear autoregressive (AR) the linear moving average (MA), the linear autoregressive moving average (ARMA) and the nonlinear Volterra models. Funding for the continuation of this work has been received.

Publications:

"The Use of Lattice Modelling for Large Scale Linear and Nonlinear Systems," with F. A. Perry and M. Romeo, 1980 IEEE International Conference on Circuits and Computers, Rye, New York, 1-3 October 1980.

"Adaptive Solutions of Multichannel Lattice Models for Linear and Nonlinear Systems," with F. A. Perry, 1980 IEEE International Symposium on Circuits and Systems Proceedings, pp. 744-747, Vol. 3, 80CH1564-4.

"An Autoregressive Moving Average (ARMA) Discrete Nonlinear Model," 1980 IEEE International Symposium on Circuits and Systems Proceedings, pp. 918-920, Vol. 3, 80CH1564-41.

"Recursive Solutions for Zero-Pole Modelling," with F. A. Perry, 13th Asilomar Conference on Circuits, Systems, and Computers, Nov. 1979, pp. 509-512, IEEE Catalog #79Ch1468-8C.

"Reduced Order Modelling of Analog Circuits," presentation at the 1979 IEEE International Symposium on Circuits and Systems, Tokyo, Japan. Seminar presentations at Kobe University and Tokyo University, Japan.

Thesis  
Directed:

F. A. Perry, "Parametric Modelling of Linear and Nonlinear Systems," Ph.D Thesis, June 1980.

**Title:** Computer Aided Acoustic Imaging

**Investigator:** John P. Powers, Associate Professor of Electrical Engineering

**Sponsor:** National Science Foundation

**Objective:** This project investigates the verifications of the use of the computer to produce images from complex valued scalar diffraction patterns produced from reflected or transmitted ultrasound. A coherent detector is scanned through the diffraction pattern and the amplitude and phase are recorded. A computer performs the image formation and image processing.

**Summary:** Work proceeded in the two areas of data acquisition and image display. The data acquisition system was refined and data from test objects was collected. Design was begun on a microcomputer system to control the detector scan and data collection with more efficiency and faster speed. On the image display side programs were written to read the data and display the image on two display systems. One system is a Ramtek color display that allowed the use of psuedo-color displays and an investigation into color assignment. The second system was an Eyecon image processing system with a library of software routines to perform processing. These routines were studied for their efficacy in processing the experimental data. Work was initiated in applying a newer, more powerful image processing system to the data.

**Publication:** J. P. Powers, R. Carlock and R. Colton, "Data Acquisition System for Computer Aided Coherent Acoustic Imaging," Acoustical Imaging, Vol. 9, K. Wang Ed. pp 643-652, Plenum Press, New York 1980.

**Conference Presentation:** J. P. Powers, R. Carlock and R. Colton, "Data Acquisition System for Computer Aided Coherent Acoustic Imaging." Presented at the Ninth International Symposium on Acoustic Imaging, Houston, Texas, 3-6 December 1979.

Theses  
Directed:

Eugene Moon, "A 16-Level Color Display  
System for Two Dimensional Ultrasonic  
Data," Master's Thesis, 1979.

Harry Vasquez, "A 256 Gray Level Image  
Processing System for Two Dimensional  
Ultrasonic Data," Master's Thesis, 1980.

**Title:** Fiber Optics in Underwater Range Applications

**Investigator:** John P. Powers, Associate Professor of Electrical Engineering

**Sponsor:** Naval Underwater Warfare Engineering Station

**Objective:** This project is investigating the feasibility and design on fiber optic communications in underwater torpedo ranges.

**Summary:** Candidate fiber optic cables have been identified. Engineering design analysis of both short range and long range links have been done identifying source and receiver parameter values. Signal spreading via pulse coding appears especially attractive for the longer link and has been demonstrated in the laboratory. An IC analog signal simulator and a microprocessor controlled simulator have also been implemented. In the area of modulation format a PCM link has been designed and tested. An analog link is currently under design as is a video uplink.

**Theses  
Directed:**

D. N. Nicholson, "Fiber Optic Link Design for an Open Ocean Shallow Water Tracking Range," Master's Thesis, 1980.

D. A. Andersen, "A Pulse Code Modulated Fiber Optic Link Design for Quinault Underwater Tracking Range," Master's Thesis, 1980.



STUDENTS OF THE DEPARTMENT OF ELECTRICAL  
ENGINEERING IN THE OPTICAL ELECTRONICS  
LABORATORY INVESTIGATING VIDEO TRANSMISSION  
BY OPTICAL FIBERS.

Title: Techniques of Acousto-Optical RF Signal Analysis

Investigator: John P. Powers, Associate Professor of Electrical Engineering

Sponsor: None

Objective: This paper investigates techniques of optically excising various frequency components within a wideband RD signal. The excision is performed in the transform domain of a Bragg cell processor. Our objective is to develop a first order model relating the laser beam, Bragg cell, excisor and detector parameters. This involves working in time, frequency and space domains since they are all inter-related by this system. An experimental test bed is also being constructed.

Summary: Filtering and recovery of the filtered signal by heterodyne detection have been demonstrated in the lab. Effects of diffraction around the excising element have been studied and various apodizing excision elements were investigated. Signal-to-noise and signal-to-interference ratios were calculated and investigated for various combinations of signal beam and excisor locations and shapes. A single frequency Bragg diffraction computer model was found in the literature and copies of the program obtained and implemented. Extension of this program into multiple frequencies is necessary for complete modeling of the system and is currently under investigation.

Thesis  
Directed: D. E. Smith, "Acousto-Optic Spectral Excision of Narrow-Band Interference," Electrical Engineer's Thesis, 1980.

Title: Development of Acoustic Imaging System for Use in Torpedo Recovery

Investigator: G. L. Sackman, Associate Professor of Electrical Engineering

Sponsor: Naval Undersea Warfare Engineering Station

Objective: This project is devoted to development of an acoustic image system for locating and classifying objects buried in bottom sediment underwater.

Summary: Preliminary calculations have been made, and two separate experimental tests have been conducted using a side-scan sonar and sub-bottom profiler modified to investigate the parametric effect as a candidate transmitter. Preliminary results of a computer simulation of a digital beamformer as a candidate receiver and display have been obtained.

Publication: G. L. Sackman, "Progress Report - Acoustic Imaging in Sediment," NPS Technical Report, NPS62-80-020 PR, November 1980.

Thesis  
Directed: G. R. Vermander, "Acoustic Imaging Processor," Master's Thesis, December 1980.

Title: Trace Function Beamformer for a Circular Array

Investigator: G. L. Sackman, Associate Professor of Electrical Engineering.

Sponsor: Naval Ocean Systems Center

Objective: This project is an experimental verification of the theory developed by S. C. Shelef in his doctoral dissertation.

Summary: The cross-spectral matrix for a small circular array of microphones receiving a tonal signal masked by white noise was measured and the bearing to the signals source estimated using the trace function algorithm. Results essentially cerified the digital simulation, demonstrating the ability of the technique to provide good bearing accuracy with an array diameter smaller than a wavelength.

Thesis  
Directed: G. W. Rollings, "Trace Function Beamformer for a Circular Array," Master's Thesis, June 1980.

Title: Control Systems Design Studies

Investigators: Robert D. Strum, Associate Professor of Electrical Engineering, and D. E. Kirk, Professor and Chairman of Electrical Engineering

Sponsor: Strategic Systems Projects Office

Objective: Long term objectives are to investigate the utility of modern control theory in solving strategic missile control problems. Techniques to be considered include adaptive control, extended Kalman filters, robust control and model following. The short-term goal was to design a control system improvement to compensate for bending modes in next-generation ballistic missiles.

Summary: An adaptive notch filter was designed which considerably improves missile response to bending modes. Follow-on efforts will involve refinement of this design and a feasibility study for microprocessor implementation of the adaptive algorithm.

Thesis  
Directed: William L. Marks, "Adaptive Notch Filter Suppression of Bending Modes," Master's Thesis, December 1980.

Title: Development of Focal Plane Processing Techniques for Surveillance System Applications

Investigator: Tien F. Tao, Professor of Electrical Engineering

Sponsor: Air Force Space Division

Objectives: Generic study of focal plane processing and implementation for missile surveillance.  
Develop a multiple microcomputer system for simulation of focal plane processing and for onboard implementation.  
Develop and evaluate new focal plane processing algorithms.

Summary: Focal plane processing techniques of five space programs have been examined for the generic signal processing techniques of their approaches for missile surveillance. These programs are: Teal Amber, Teal Ruby, HALO (High Altitude Large Optics), MSP (Missile Surveillance Program) and Mini-HALO. Processing techniques include the end-to-end programs from optical filtering, Sensor read-out, multiplexing, encoding, pre-filtering for clutter suppression, Analog to Digital conversion, digital temporal and spatial filtering for clutter suppression, thresholding, spatial and temporal pattern tests for track acquisition, track estimation and event processing.  
  
A hierarchical bus communication multiple microcomputer system is being developed. It uses Intel's 16 bit microcomputers as the basic processing elements. Several such microcomputers are connected to a system bus to form a cluster. Several clusters are connected together by a multiple-star bus switch network into a star. Three level controllers have been developed for this intercommunication network and include: random priority controller, distributed controller and central controller. An end-to-end image processing program has been developed for a single cluster multiple microcomputer system. Using specially

coded synchronization primitives, this image processing program has been implemented on a single cluster consisting of four microcomputers demonstrating the concurrent pipeline computing. It has not been implemented on two clusters because there are still transmission errors through the inter-communication network.

New image processing algorithms have been developed for both clutter suppression and for target acquisition. Several adaptive filter approaches are being developed for processing of infrared image to improve the target signal to background clutter noise ratio. They are based on two optimization criteria: minimization of mean square error and maximization of signal to noise ratio. Several convergence techniques are being developed and compared using two real world infrared images. For acquisition of stationary target in single frame of image and moving targets in multiple frames of images, new pattern test techniques using spatial, temporal and spectral information are being developed. They have been tested on real world infrared images with good results. Three sets of multiple frames of infrared images have been used to test pattern tests based on spatial and temporal informations. Two sets of single frame images in two infrared spectral bands have been used to evaluate pattern tests using spatial and spectral information.

Conference  
Presentations:

T. F. Tao, J. Jacobsen and H. Amir, "Processing of Infrared Images for Target Acquisition," 24th Annual SPIE Symposium, Session on "Image Processing for Missile Guidance," July 29 - August 1, 1980.

R. Schell, U. Kodres, H. Amir, J. Wasson and T. F. Tao, "Processing of Infrared Images by Multiple Microcomputer System," 24 Annual SPIE Symposium, Session on "Real Time Signal Processing III," July 29 - 30, 1980.

T. F. Tao, J. Morrison, "Multiple Target Tracking," 24 SPIE Symposium, Session on "Smart Sensors II," July 31 - August 1, 1980.

T. F. Tao, H. Amir, J. Jacobsen, D. BarYehoshua and B. Evenor, "Comparison of Statistical and Deterministic Temporal/Spatial Filter for Suppression of Infrared Background Clutter," 24 SPIE Symposium, Session on "Modern Utilization of Infrared Technology VI," July 31 - August 1, 1980.

Theses  
Directed:

B. Hilimitzas, "Image Processing Studies for Detection and Tracking of Dim Targets in Multiple Frames of Infrared Images," Master's Thesis, December 1979.

E. Kolokythas, "Image Processing Implementation Using Multiple Microcomputer System," Master's Thesis, December 1979.

R. Brenner, "Multiple Microprocessor Application for Smart Sensor Focal Plane Processing," Master's Thesis, December 1979

K. Kanavariotis, "Multiple Microcomputer Implementation of Smart Sensor Processing Program," Master's Thesis, December 1979.

J. Morrison, "Focal Plane Tracker for a High Altitude Mosaic Sensor System," Master's Thesis, March 1980.

D. Becker, "Microcomputer and Array Processor Based Implementation of Infrared Image Processing," Master's Thesis, March 1980.

W. Hess, "Multiple Microcomputer Implementation of Infrared Image Processing," Master's Thesis, June 1980.

Title: Enhancement of Computing Power of 16 Bit Microcomputer by Using Microcomputer Compatible Array Processor

Investigator: Tien F. Tao, Professor of Electrical Engineering

Sponsor: NPS Foundation Research Program

Objective: Investigate and develop the concepts, approaches and skills to enhance the computing power of 16 bit microcomputers by microcomputer compatible array processor with a longer range goal to use the combination of microcomputer and array processor in a multiple microcomputer system.

Summary: Interest in using 16 bit microcomputers for signal processing applications have been increasing at a rapid rate. However, the computing capabilities of today's microcomputers are limited for real time signal processing performance. This project is to determine the limitations today and to develop new methods to enhance their signal processing capabilities. The highlights of our progress will be presented in the following.

Development of a Benchmark Test Program-Image Processing Problem: An end-to-end multiple stages image processing program for detection of moving targets in noisy images has been developed as the benchmark test program. It will be described by presenting the images at various stages of the image processing as shown in Fig. 1. It includes several signal processing steps from the statistical temporal and spatial filters for background clutter suppression, a histogram counting procedure for adaptive thresholding, and several pattern recognition operations based on spatial, temporal pattern tests for target acquisition. Their diversified computations involving floating point real numbers and integer binary/digital numbers should provide a good benchmark test.

Selection of Signal Processing Resources: Two 16 bit microcomputers have been selected as the basic microcomputers. The first one

is the DEC LSI-11 microcomputer which has a physical address space of 64 Kbytes (16 address bits). It is being used as a single stand alone microcomputer. The second one is the Intel 8612 microcomputer which has a physical address space of 1 Mbytes. It is being used as the basic processing elements in a multiple microcomputer system.

Two microcomputer-compatible array processors have been selected as the special-purposes signal processor to enhance the computation capabilities of the microcomputers. The first one is the MSP-3 array processor of the CDA, Inc. The second one is the AP4000 array processor of the Analogic, Co. Both use the block floating point data format. MSP-3 must be programmed by microprogramming. The AP4000 provides a cross-assembler which allows the user to develop new signal processing subroutines using high order programming language.

**Preliminary Results of Execution Times:** The execution time of the benchmark test image processing program has been measured on three different computer/processor combinations: An IBM 360/67 mainframe computer, a 16 bit DEC LSI-11 microcomputer and a combination of LSI-11 microcomputer and the MSP-3 array processor. For the cases of 360 and LSI-11, Fortran is used as the programming language. Single precision data format is used. For the combination of LSI-11 and MSP-3, both Fortran and Macro-Assembly language are used for comparison. The data format is either the block-floating point or the integer. Execution times of individual subroutines have been measured and listed in this table. It can be seen that the complete end-to-end program has been coded for the LSI-11 microcomputer. It is being used to determine the limitation of signal processing capability of representative 16 bit microcomputers today. The execution times on the IBM 360 are used as a reference. Using the existing firmware provided by the manufacturer, the MSP-3 array processor has been able to enhance the computation power of the LSI-11 microcomputer in the temporal

and spatial filtering subroutines coded in Fortran on the LSI-11. However, because of the unavailability of appropriate firmware subroutines, the computation of both the temporal and spatial statistics have not been helped by the array processor at all. In fact, the computation time for the temporal statistics was increased almost three times. However, if Macro-Assembly language is used, better programming and data manipulation are possible as indicated by the reduction of execution times. It can be seen that the combination of a microcomputer and an array processor can be almost as efficient as the mainframe computer in these image processing computations. Further, if the integer format is used, the performance in execution times even surpass that of the mainframe computer.

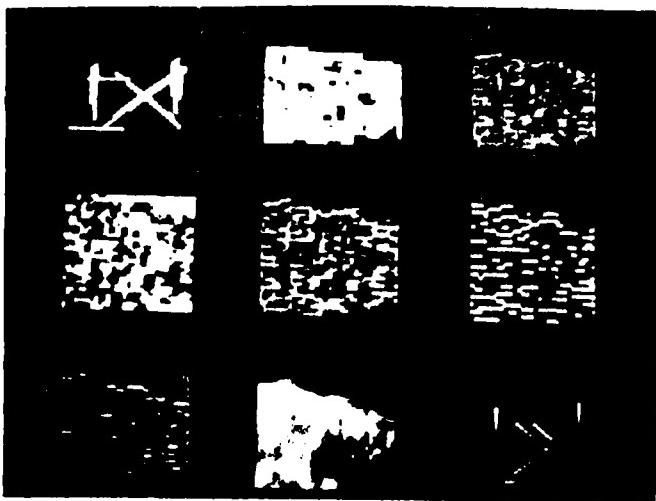
Theses  
Directed:

K. Celik, "Focal Plane Signal Processing for Clutter Suppression and Target Detection in Infrared Images," Electrical Engineer's Thesis, June 1979.

D. Becker, "Microcomputer and Array Processor Based Implementation of Infrared Image Processing," Master's Thesis, March 1980.

W. Hess, "Multiple Microcomputer Implementation of Infrared Image Processing," Master's Thesis, June 1980.

**Demonstration of End-to-end Processing of Infrared Images  
For Detection of Very Dim Moving Targets  
In Space Surveillance Applications**



<b>Simulated targets:</b> 5 moving point targets 1 stationary track Target intensity 50 db below the mean of the Santa Cruz image	<b>Infrared background clutter image:</b> LWIR image taken from HCMM satellite Santa Cruz, California	<b>Result of background clutter suppression by temporal and spatial filtering</b> 3 frame temporal 3x3 spatial
<b>Single frame result after the thresholding step</b>  <b>250 hits collected for a single frame</b>	<b>Results of the 3rd step of processing</b>	
	<b>Composite image of 13 frames: Positive signal</b>  <b>Positive Composite</b>	<b>Composite image of 13 frames: Negative signal</b>  <b>Negative Composite</b>
<b>Result of the 3rd step of processing:</b>  <b>Final Composite image</b> "Logic AND" combination of both Positive Composite and Negative Composite images	<b>Results of the 4th step of processing</b>	
	<b>Decaled tracks after the application of a "5 out of 10" spatial pattern test without using temporal information</b>	<b>Declared tracks after the application of a "5 out of 10" pattern test considering both spatial and temporal information</b>

- IMPORTANT POINTS:**
1. Statistical temporal and spatial filters are effective in suppressing background clutter
  2. Target acquisition techniques using both spatial and temporal information are very effective such that a large number of hits can be collected in each frame (250 hits out of 1024 detectors)
  3. 4 of the 5 dim tracks (50 db below) can be detected together with 2 false tracks.

Fig. 1

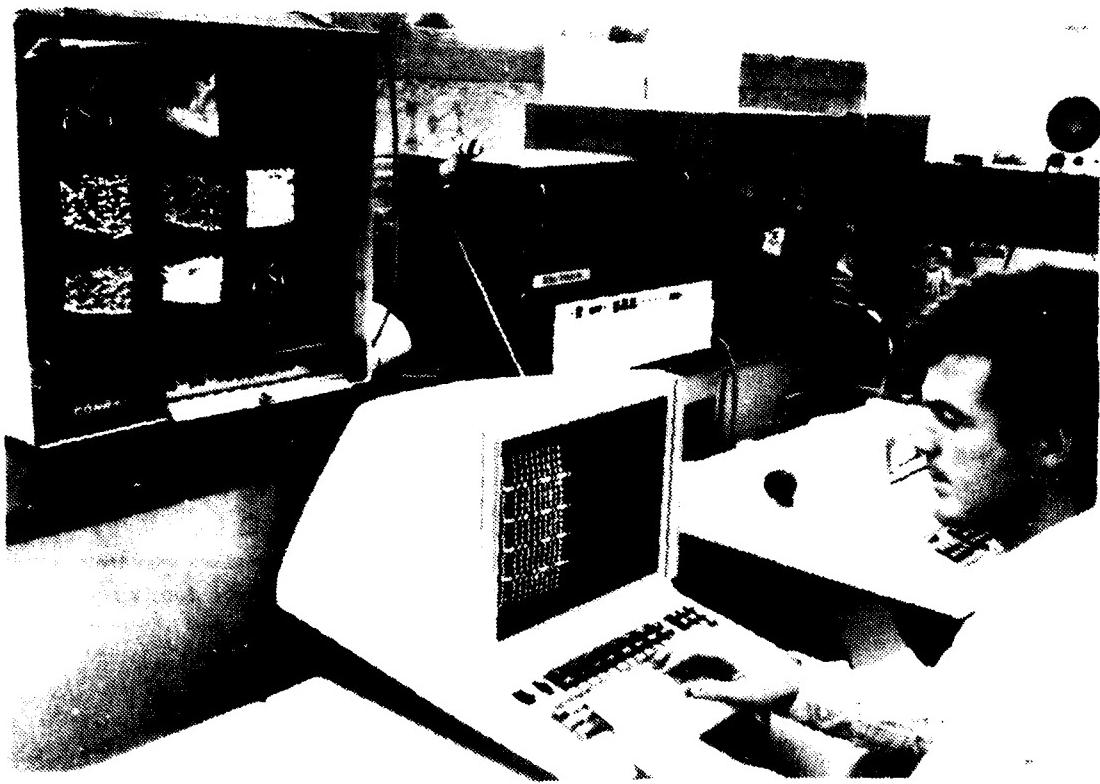


IMAGE PROCESSING RESEARCH USING  
16 BIT MICROCOMPUTER SYSTEM  
ENHANCED BY AN ARRAY PROCESSOR.

Title: AEGIS Systems Research

Investigator: Harold A. Titus, Professor of Electrical Engineering

Sponsor: Naval Sea Systems Command

Objective: To analyze the effects of various ECM against the AEGIS Missile Systems.

Summary: A simulation was conducted on ECM against the SM-2. Cooperative countermeasures and maneuvers were employed. LCDR D. Gunn's thesis, "Simulation of SM-2 Standard Missile in a Dual Target Blinking Jamming Environment," reported on this effort. A paper was presented at the Tri-Service ECM Symposium on this material. Another student is presently completing his work on an adaptive tracking algorithm for the SPY-1 radar in an ECM environment with possible external inputs.

Title: Evaluation, Simulation and Analysis for the Crossbow Committee

Investigator: Harold A. Titus, Professor of Electrical Engineering

Sponsor: Army Missile Research and Development Command

Objective: To provide consultation to the missile intelligence committee, including simulations.

Summary: The missile simulations at Eglin, AFB, were analyzed and compared with some developed at NPS. The SA-6 and Hawk missiles were evaluated against an ECM environment.

A hardware study was conducted on angle gate steal against a conical scan radar.

Our recent efforts have centered around simulations of ECM and tactics against possible threat missiles. We have restricted our work to surface to air missiles of the SA-6 and Hawk (of Iran) variety. It is quite difficult to assess these techniques on test range because they are directed against the missile as opposed to the ground radar.

The techniques include cooperative countermeasures and aircraft maneuvers, and angle gate steal.

Title: Multi-Source Track Management (MSTM)

Investigator: Lonnie A. Wilson, Associate Professor of Electrical Engineering

Sponsor: Naval Sea Systems Command

Objective: To provide theoretical analysis and system tradeoff analysis for the MSTM function of the Advanced Combat Direction System. Automatic target track management and multi-source identification (MSID) processing architectures and algorithms will be developed, analyzed and evaluated.

Summary: This program is essentially to develop the advanced NTDS concept for the 1990's in the U. S. Navy. This program was a mid-year new start and most of the technical efforts were related to attending program technical reviews and contributing during reviews.

Title: Ship Classification Techniques Using  
Tactical Sensors

Investigator: Lonnie A. Wilson, Associate Professor of  
Electrical Engineering

Sponsor: Naval Air Systems Command

Objective: To provide theoretical analysis and system  
tradeoff analysis between Navy target  
classification developments. Also, to  
develop a computer-aided target classifi-  
cation system using a FLIR sensor.

Summary: Several ship classification system  
architectures have been analyzed and  
preliminary analysis information have  
been conveyed to the sponsor in verbal  
form.  
  
Additional efforts will be completed  
next fiscal year.

Thesis  
Directed: M. L. Maurer, "A Dimensionality Reduction  
Technique for Enhancing Information  
Context," Master's Thesis, June 1980.

Title: Battle Assessment for C3

Investigators: John M. Wozencraft, Chairman, Command, Control and Communications Academic Group, and Professor of Electrical Engineering, Norman R. Lyons, and Roger Weissinger-Baylon, Associate Professors of Administrative Science

Sponsor: Naval Electronic Systems Command

Objective: The study is to investigate the effects of battle related factors such as tactics, doctrine, environment, mission and threat on information content and transfer requirements. The purpose is to provide guidelines for the development of Navy Command and Control Systems.

Summary: This is part of a continuing program. The activity to date has consisted of meetings and literature searches to define the nature of the problem and learn about past approaches.

Publications: Roger Weissinger-Baylon, CAPT Wayne Hughes, Scott Adams and Anne Weissinger-Baylon, "Analyzing Executive Decision Making Processes: The Methodological Contribution of Visual Mental Imagery," Proceedings of the Conference on Information Systems, Philadelphia, Penn., December 1980.  
Roger Weissinger-Baylon and Ivar Tonisson, "A Study of Communication Errors," Proceedings of the 7th Annual Meeting of the Berkeley Linguistic Society, Berkeley, California, February 1981.

Title: Research in Communications, Command, Control and Intelligence

Investigators: J. Wozencraft, Chairman Command, Control and Communications Group, D. P. Gaver, Professor of Operations Research, P. Moose, Associate Professor of Electrical Engineering, and F. Russell Richards, Associate Professor of Operations Research

Sponsor: Defense Advanced Research Projects Agency

Objective: To develop basic conceptual frameworks for C<sup>3</sup>I; to develop and compare weaknesses and strengths of simulations, war games, and exercises as C<sup>3</sup>I research tools; and to develop and test interdisciplinary measures for evaluating the effectiveness of proposed improvements in C<sup>3</sup>I.

Summary: Combat Modeling

The problem of the efficient distribution of multi-commodity resources over a capacitated network has been investigated. The objective is taken to be minimization of the total delivery time, plus maximization of the total amount of commodities delivered subject to this time constraint. It has been shown that the solution can be obtained by a sequence of linear programs and has the form of a piecewise-linear convex curve. The work is continuing, and a report is being written.

## DEPARTMENT OF METEOROLOGY

The research program in the Department of Meteorology continues in several areas: (1) numerical weather and ocean modeling and prediction, (2) analysis and dynamics of tropical weather systems, (3) marine atmospheric boundary layer studies, (4) marine fog/Visibility analysis and prediction, (5) polar studies and (6) satellite remote sensing. Under each of these headings, a number of related investigations have been pursued by various faculty members.

### NUMERICAL MODELING AND PREDICTION

R. T. Williams is developing and testing numerical procedures for global and regional weather prediction. He is investigating various finite element formulations with respect to geostrophic adjustment. He will apply the techniques to the prediction of air flow near mountains, and to tropical cyclones. Professor Williams has also modified an existing model to determine better the changes which occur in frontal structure when a front moves over a surface where moisture and temperature properties are changing.

R. L. Elsberry and R. W. Garwood, Jr. (Oceanography) have used a one-dimensional mixed-layer model to predict the upper ocean response to atmospheric forcing, and have successfully simulated the Mixed Layer Experiment. In a joint effort with R. L. Haney, the mixed-layer model has been embedded into an oceanic general circulation model. This hybrid model is a first in oceanographic applications and may represent a breakthrough in the numerical simulation of upper ocean dynamics. This new model will not be used in a variety of oceanic investigations including the response of the ocean to tropical and extratropical storms (Elsberry) and the dynamics of large scale anomalies observed in the North Pacific Ocean (Haney).

Other modeling efforts include a dynamical-statistical model for predicting the movement of tropical cyclones by R. L. Elsberry, a marine boundary layer model for predicting marine aerosol distributions on EM propagation conditions by K. L. Davidson, and the beginning of a comparison of several global initialization schemes by a Ph.D. candidate under the direction of Professors G. J. Haltiner and R. T. Williams.

### ANALYSIS AND DYNAMICS OF TROPICAL WEATHER SYSTEMS

C. P. Chang, R. L. Elsberry and R. T. Williams are investigating various aspects of the dynamics of tropical weather systems, including development of hurricanes and typhoons by

Elsberry, the dynamics and energetics of tropical synoptic and planetary scale waves by Chang and Williams, and the diagnostic analysis of winter and summer monsoon circulations by Chang.

C. P. Chang and K. M. Lau are using domain-averaged climatic numerical models to investigate the various mechanisms pertinent to the large-scale interaction between the tropical atmosphere and oceans. Among the phenomena being studied are the Walker circulation, the Hadley circulation and the El Nino fluctuations.

One of the NAVAIRSYSCOM Research Chair incumbents in FY 80, William M. Gray, completed a research study on observational and theoretical aspects of tropical cyclone genesis.

#### MARINE ATMOSPHERIC BOUNDARY LAYER STUDIES

Research in this area includes several interdisciplinary observational and theoretical projects involving Professor K. L. Davidson. Objectives of the individual projects are: 1) to evaluate and formulate models which relate changes in the depth and structure of the atmospheric mixed layer (capped by an inversion) to surface fluxes and sky conditions, 2) to evaluate and formulate models for equilibrium marine aerosol distributions, 3) to establish synoptic scale descriptions of the magnitude and height variations of optical turbulence, 4) to relate near surface aerosol distributions to white-cap coverage and 5) to determine pollutant dispersion properties of the atmospheric boundary layer in the California coastal region.

Two of the NAVAIRSYSCOM Research Chair occupants in FY 80, Hans A. Panofsky and Robert A. Brown, contributed to K. L. Davidson's boundary layer research in the areas of turbulence and boundary layer modeling, respectively.

#### MARINE FOG/VISIBILITY ANALYSIS AND PREDICTION

An interdisciplinary project involving R. J. Renard, W. van der Bijl and faculty members from the Department of Oceanography and Operations Research is concerned with the analysis and numerical/statistical prediction of fog over open ocean and coastal regimes, both on a regional and hemispheric scale. On a regional basis a marine fog sequential development model is under study for the Eastern North Pacific Ocean coastal area and an open ocean version for the Gulf of Alaska area. On a whole ocean basis, a numerical model output statistics scheme is being applied to marine fog and visibility over the North Pacific Ocean poleward of 30N.

#### POLAR WEATHER STUDIES

Currently R. J. Renard's research is concerned with the observational network commensurate with synoptic/mesoscale weather events over the Antarctic area. In addition to data from conventional and satellite sources, data from remote automatic weather stations and the Airborne Research Data System (ARDS) aboard an LC-130R aircraft have been analyzed for their contributions both to the scientific and operational weather endeavors in support of the U.S. mission in Antarctica.

#### SATELLITE REMOTE SENSING

Professor K. L. Davidson is involved with observational studies concerned with surface truth evaluation of satellite borne scatterometer derived estimates of the oceanic surface layer wind and satellite borne microwave radiometer derived estimates of the sea-surface temperature. Furthermore, aerosol distribution data obtained off the California coast are being used to assess the role of atmospheric extinction of 'grey shade' patterns within usual satellite imagery (DMSP).

Title: Synoptic and Numerical Studies of Disturbances Over Tropical Oceans

Investigator: Chih-Pei Chang, Associate Professor of Meteorology.

Sponsor: Naval Air Systems Command

Objective: To identify the typical structure and behavior of low-latitude synoptic disturbances over oceans.

Summary: Synoptic scale weather disturbances over the tropical and subtropical part of the Western Pacific and adjacent seas are analyzed using conventional and radiosonde data. The dynamic and thermodynamic structure of the early summer monsoon trough (Plum Rain Systems) have been determined and its numerical simulation are in process. The disturbances associated with the northern winter monsoon in the South China Sea will be analyzed. The characteristics of these synoptic systems will be compared to Naval numerical global models for model performance evaluation purposes.

Publication: T. J. Chen, C. P. Chang, 1980: The Structure and Vorticity Budget of an Early Summer Monsoon Trough (Mei-Yu) Over Southeastern China and Japan, Monthly Weather Review, 108, #7, 943-953.

Title: Temporal and Spatial Variations of Large-Scale Tropical Flows

Investigator: Chih-Pei Chang, Associate Professor of Meteorology

Sponsor: National Oceanic and Atmospheric Administration

Objective: To study the seasonal and intra-seasonal variations of planetary scale tropical circulations.

Summary: The inter-relationship between planetary scale motions over Asia, western Pacific and Indian Ocean are studied by a diagnostic analysis of the kinematic properties of the 200 mb flows over four winter seasons. The objectively analyzed wind field has been used to calculate and composite the structure of variations of several circulation features, including the jet streams over East and West Asia and the local Hadley and Walker Circulations. Results indicate a definitive relationship between these variations during winter monsoon surge periods.

Publications:

C. P. Chang, K. M. Lau, "Northeasterly Cold Surges and Near-Equatorial Disturbances Over the Winter MONEX Area During December 1974. Part II: Planetary Scale Aspects," Monthly Weather Review, 108, #3, 1980, 293-312.

C. P. Chang, K. M. Lau, "Planetary Scale Motions of Winter Monsoons During Cold Surge and Monsoon Break Periods," accepted by GARP Publication Series, Early Results of FGGE and MONEX, 1980.

C. P. Chang, K. M. Lau, "Oscillations of Planetary Scale Motions During Winter Monsoons," submitted to Monthly Weather Review, 1980.

Title: Tropical and Monsoon Dynamics

Investigators: Chih-Pei Chang, Associate Professor of Meteorology, and R. T. Williams, Professor of Meteorology

Sponsor: National Science Foundation

Objective: To study the structure and dynamics of large-scale flow in the tropics and subtropics. This is a continuing research project.

Summary: The research project includes several parts:  
i) The synoptic study of cold surges and equatorial disturbances during the Winter Monsoon Experiment. The quick look data set over the South China Sea region has been analyzed to complete a map series for the wind field at four levels of the lower troposphere. The analyzed data will be used to study the surges and disturbances. ii) The diagnostic study of planetary scale motions during winter monsoons. Strong cold surge cases and anti-surge (break) periods during three winter seasons (1973 74, 74-75 and 75-76) have been composited to identify inter-relationships between the variations of several planetary scale circulation components, in order to elucidate their dynamics. iii) The non-linear barotropic motions associated with a zonally-varying easterly jet basic flow. A numerical model was used to examine the disturbance motions developed in the jet vicinity under the influence of varying instabilities. Time series analysis of the equilibrium state is being performed to study the barotropic dynamics associated with monsoon jets.

Publications: C. P. Chang, K. M. Lau, "Northeasterly Cold Surges and Near-Equatorial Disturbances Over the Winter MONEX Area During December 1974, Part II: Planetary Scale Aspects," Monthly Weather Review, 108, #3, 1980, 293-312.

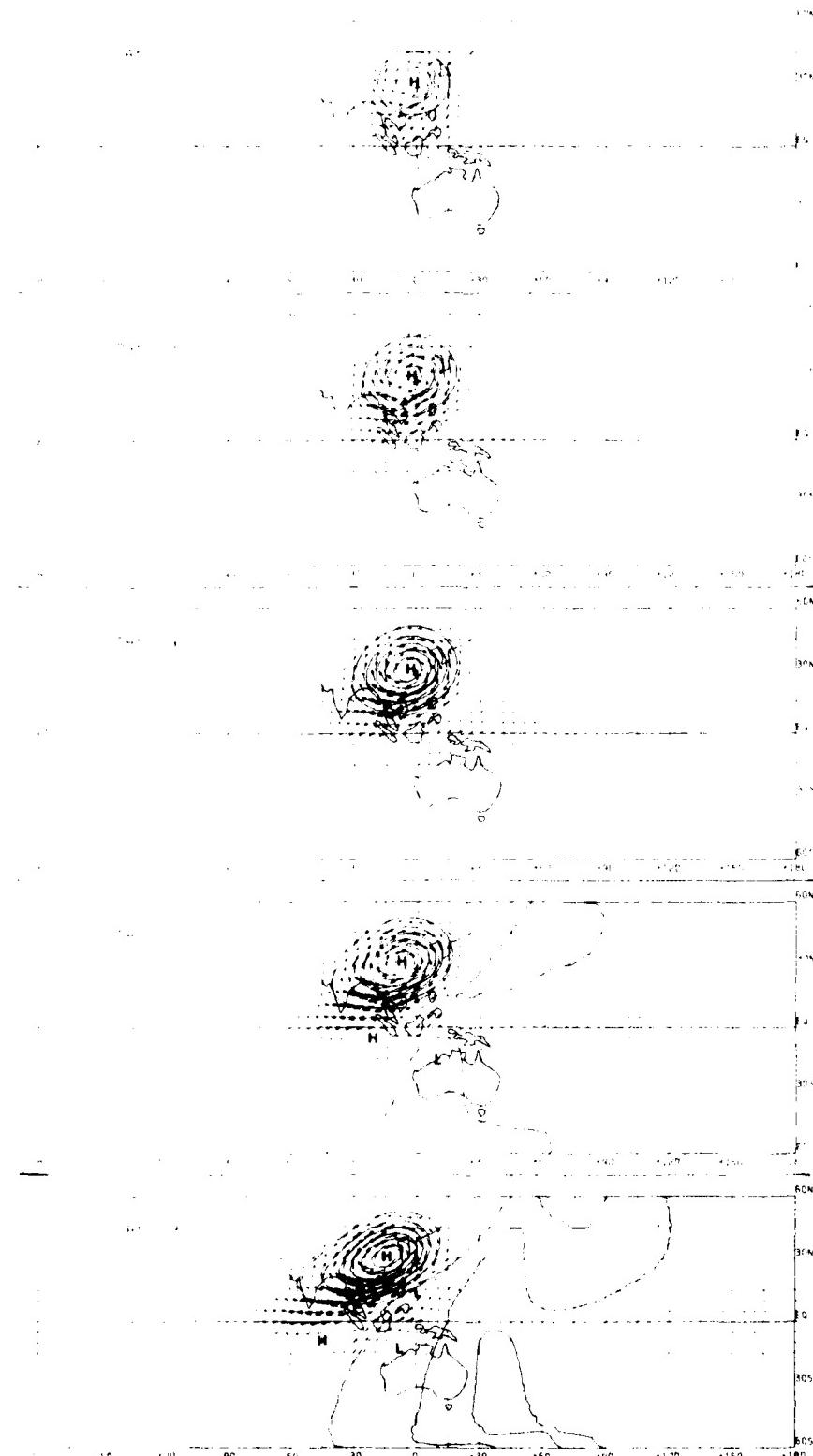
C. P. Chang, K. M. Lau, "Planetary Scale Motions of Winter Monsoons During Cold Surge and Monsoon Break Periods," accepted by GARP Publication Series, Early Results of FGGE and MONEX, 1980.

C. P. Chang, K. M. Lau, "Oscillations of Planetary Scale Motions During Winter Monsoons," submitted to Monthly Weather Review, 1980

Hock Lim, C. P. Chang, "A Linear Theory for the Northern Winter Monsoon Surges," submitted to Journal of Atmospheric Sciences, 1980.

Conference Presentation:

C. P. Chang, "A Quick Look Analysis of Synoptic Scale Disturbances of Winter MONEX," 6th International Planning Meeting for MONEX Singapore, 5-9 November 1979, abstract in Report of the 6th Planning Meeting for MONEX, International Council of Scientific Unions and World Meteorological Organization, K-4, 1979.



COMPUTER OUTPUT FROM PROFESSORS CHANG AND WILLIAMS MATHEMATICAL MODEL OF TROPICAL RESPONSES TO MID-LATITUDE FORCING DUE TO MONSOON SURGES DURING WINTER, USING THE EQUATORIAL BETAPLANE THEORY (TROPICAL AND MONSOON DYNAMICS RESEARCH PROJECT).

**Title:** Analyses and Interpretation of White Cap,  
Surface Stress and Aerosol Data

**Investigators:** K. L. Davidson, Associate Professor of Meteorology and Jorgen Hojstrup, Adjunct Professor of Meteorology

**Sponsor:** NPS Foundation Research Program

**Objective:** Perform joint analysis on aerosol size, distribution surface stress and "white-cap" data, obtained in Northeast Atlantic during JASIN-78, to formulate relationship between local aerosol production and "white-cap" coverage.

**Summary:** The role of local production on equilibrium aerosol distribution and procedures for estimating the production rate were sought from this rather unique data set which coupled aerosol, surface stress and white cap data. To do this, other factors influencing the equilibrium distributions had to be accounted for by suitable normalization. These factors were the relative humidity growth effect and surface layer transport intensities. Normalizations were performed on the observed aerosol distributions using accepted procedures (Fitzgerald, JAM, 1976; Lovett, Tellus 1979; Toba, Tellus, 1965) but yielded results with too large uncertainties to establish an empirical white-cap - number concentration relationship. The standard deviation of aerosol mass within an average wind category was larger than the change over the entire wind speed range. These results led to a conclusion that additional normalization is required before observed concentrations and white cap coverages can be correlated. Candidate parameters for this scaling are the depth of the atmospheric well mixed layer and the entrainment rate at the marine inversion.

Publications:

A description of the results was presented to sponsors of our aerosol modeling-measurement work (NAVMAT, NAVAIR). They have agreed to support parallel measurements in the Gulf of Alaska during November and December 1980 in order to increase data base necessary for further analyses. ONR (Paul Twitchell, Boston) solicited a proposal to extend analyses of available data and a proposal has been prepared and is being submitted.

**Title:** Development of Stability Dependent Surface Layer Aerosol

**Investigator:** K. L. Davidson, Associate Professor of Meteorology

**Sponsor:** Naval Environmental Prediction Research Facility

**Objective:** Relating equilibrium sea-salt aerosol concentrations to surface layer and mixed layer parameters.

**Summary:** This research effort consists of examinations of both aerosol balance and surface layer turbulence to establish concentrations of locally generated aerosols. The approach is based on a balance in which equilibrium aerosol distributions depend on the roles local generation, relative humidity and transport. The role of transport has received the least attention in existing empirical models. Recent understanding of the stability influence on transport have been applied. The goal is to relate observed aerosol distributions to these bulk parameters. It has been established that entrainment processes at the top of the well mixed boundary layer must be included in the balance expressions. When the removal scaling velocity is determined by entrainment scaling velocities for the entire mixed layer the magnitude as well as the trend of predicted transport influences agree with observed results.

**Publications:**

A. Goroch, S. Burk and K. L. Davidson, "Stability Effects on Aerosol Size and Height Distributions," Tellus, 32, 245, 1980.

K. L. Davidson, "Stability Influence on  $\text{SO}_4^{2-}$  Aerosol Concentrations Observed in the North Atlantic," NPS Technical Report, NPS63-79-006, December 1979, 73 pp.

L. Schutz and K. L. Davidson, "Observational Results on the Influence of Stability on Surface Layer Aerosol Concentrations," Proceedings, Aerosols in Science, Medicine, and Technology (GAF), Graftschaft/Schmallenberg F. R. G., October 1980, 7 pp.

**Title:** Observational Studies on Marine Boundary Layer Processes

**Investigators:** K. L. Davidson, Associate Professor of Meteorology, and G. Schacher, Associate Professor of Physics and Chemistry.

**Sponsor:** Naval Air Systems Command

**Objective:** Prediction of the evolution of a marine atmospheric boundary layer.

**Summary:** This research program consists of a boundary layer model development effort and an experimental field program. The modeling effort is based on the empirical relation of entrainment at the top of the layer to the surface fluxes. The intention is to allow prediction of boundary layer evolution from routine shipboard radiosonde and future surface layer winds. The model includes the effects of subsidence and cloud radiative cooling. The experimental program has historically focused on verification from shipboard measurements of the surface layer scaling laws used in the model. More recently, the field work was expanded to aircraft measurements of mean and turbulent parameters. An observational experiment was conducted in May 1980 in which aircraft and shipboard measurements were coordinated to observe temporal and spatial factors in the zero order models.

**Publications:**

J. Jarell, J. Ernst, G. Schacher and K. Davidson, "Wind Wave Coupling in SEASAT Surface Truth Interpretations," SEASAT Colloquium.

K. Davidson, G. Schacher, C. Fairall, and T. Houlihan, "Observations of Atmospheric Mixed-Layer Changes off the California Coast," Proceedings at 2nd Conference on Coastal Meteorology, January 1980, 63-71.

K. L. Davidson and V. Noonkester, "Observations of the Occurrence of Encroachment within the Marine Atmospheric Boundary Layer (CEWCOM-76)," Proceedings of 2nd Conference on Coastal Meteorology, January 1980, 284-287.

G. Schacher, K. Davidson, and C. Fairall, "Observation on Turbulent Kinetic Energy Dissipation Rates, over the Ocean," accepted by Boundary Layer Meteorology.

K. Davidson, T. Houlihan, C. Fairall, and G. Schacher, "Observation of the Temperature Structure Function,  $C_T^2$ , Over the Ocean," Boundary Layer Meteorology, 15, 507 (1978).

C. Fairall, G. Schacher, K. Davidson, T. Houlihan, "Atmospheric Marine Boundary Layer Measurements in the Vicinity of San Nicolas Island During CEWCOM-78," Proceedings of 2nd Conference on Coastal Meteorology, January 1979, 71-75.

C. Fairall, R. Markson, G. Schacher, K. Davidson, "An Aircraft Study of Turbulence Dissipation and Temperature Structure Function in the Unstable Marine Atmospheric Boundary Layer," accepted by Boundary Layer Meteorology.

**Title:** Puff-Model Calculations of Smoke Obscurations

**Investigators:** K. L. Davidson, Associate Professor of Meteorology, and G. E. Schacher, Associate Professor of Physics and Chemistry.

**Sponsor:** Naval Research Laboratories

**Objective:** Perform calculations of three-dimensional concentrations of released obscuration smoke using an available puff-model.

**Summary:** Smoke dispersion estimates were needed for making decisions on the best release procedures in an overwater experiment conducted by NRL personnel in late FY 80. It was determined that existing quassian plume models were inadequate because of the short-term and near-region aspects of the experiment. A puff dispersion model recently developed by investigators at the RISO National Laboratories (RNL), Denmark, was made available to NPS investigators during K. Davidson's sabbatical leave at RNL. Representative wind and turbulent conditions for the experiment location were used with the puff model to obtain estimates of dispersion for different release procedures. These estimates indicated that the only procedure which would yield the desired spatial and temporal observation was to have a helicopter translate the point source upward of and diagonally across the desired obscuration range. The experiment was performed with the suggested procedures and the desired obscuration conditions were observed.

**Publication:** K. L. Davidson, and J. Hojstrup, "Puff-Model Calculations," Memorandum Report, Transmittal Letter NC4 (63Ho)/mn, 13 June 1980, 8 pp.

Title: Turbulent Determination of  $C_n^2$

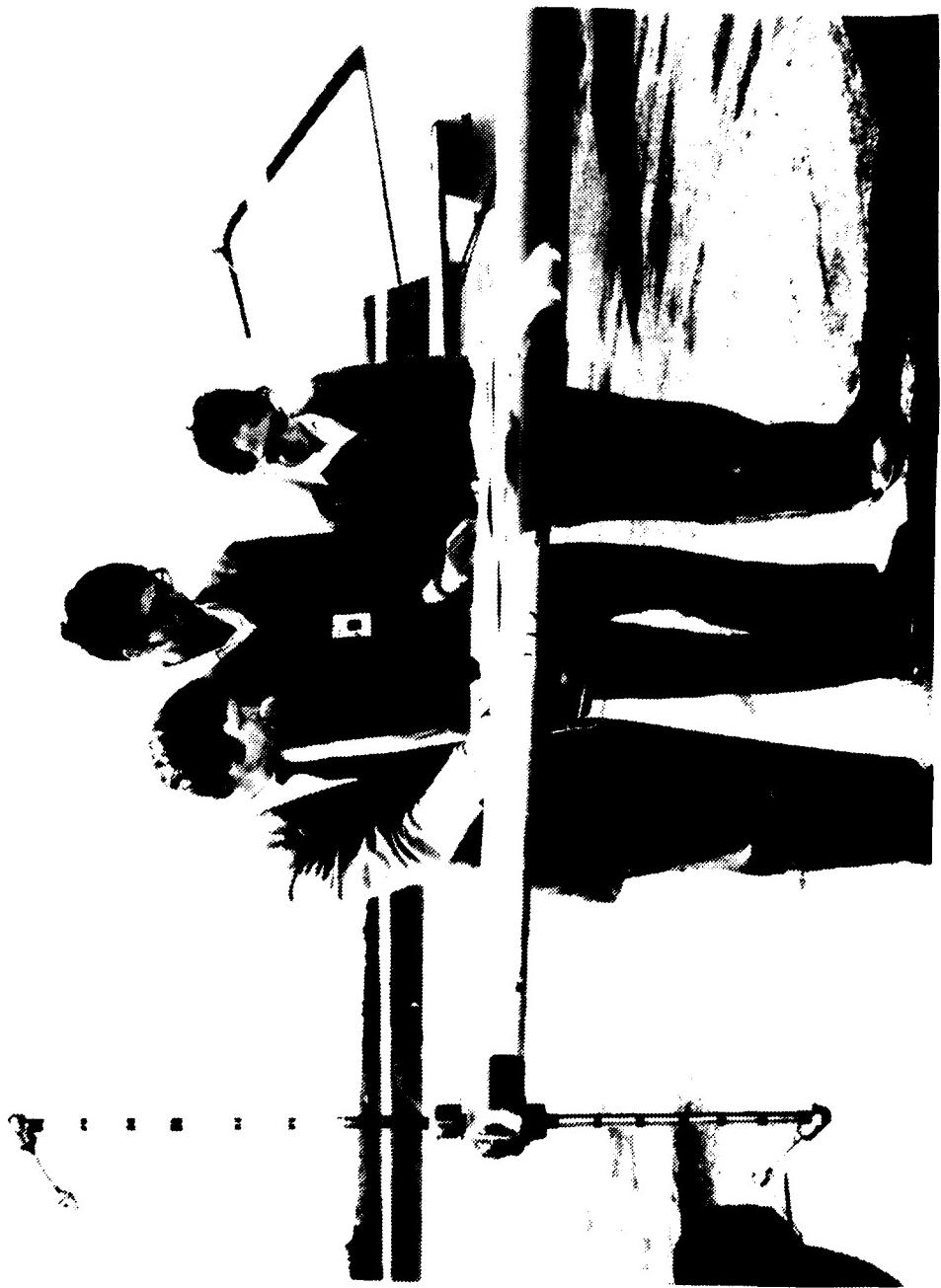
Investigators: K. L. Davidson, Associate Professor of Meteorology, and G. E. Schacher, Associate Professor of Physics and Chemistry.

Sponsor: Naval Environmental Prediction Research Facility

Objective: Obtain turbulent estimates of the optical index of refraction structure function parameter,  $C_n^2$ , in conjunction with optical estimates. Evaluate approaches for relating  $C_n^2$  to bulk surface layer parameters, wind, temperature and humidity.

Summary: Over the ocean optical turbulence is significantly influenced by humidity fluctuations as well as temperature fluctuations. Observational and theoretical capabilities exist to relate optical turbulence levels to both mean and turbulent properties of the marine atmospheric surface layer. Remaining uncertainties on the role of the humidity fluctuation effect and its scaling by bulk parameters required a combined over water meteorological-optical experiment. This experiment was conducted in May 1980 in Monterey Bay. Comparison of optical, turbulence and bulk derived  $C_n^2$  values showed that optical, and bulk derived values are in the best agreement; within 30%. An important determining parameter in bulk value estimates was the surface temperature. It was shown that uncertainties in the skin temperature resulted in a bucket temperature being the best surface description. Horizontal gradients of the surface temperature were a factor in the comparisons because they led to the local turbulence not being in equilibrium with the boundary conditions.

Publication: K. L. Davidson, G. E. Schacher, C. W. Fairall, D. E. Spiel, E. C. Crittenden, Jr., and E. A. Milne, "Verification of the Bulk Model for Calculations of the Overwater Index of Refraction Structure Function,  $C_n^2$ ", NPS Technical Report, NPS61-80-016, 1980<sup>n</sup>, 41 pp.



PROFESSOR K. DAVIDSON, DR. CHRIS FAIRALL (BDM) AND DR. RALPH MARKSON (AIRBORNE RESEARCH ASSOCIATES) EXAMINING AIRBORNE TURBULENCE DATA OBTAINED IN OVERWATER MEASUREMENTS, MAY 1980.

Title: Modeling Upper Ocean Thermal Structure

Investigators: Russell L. Elsberry, Professor of Meteorology and Roland W. Garwood, Jr., Assistant Professor of Oceanography.

Sponsor: Naval Ocean Research and Development Activity

Objective: Application of a one-dimensional oceanic boundary layer model for prediction of the upper ocean thermal structure.

Summary: Our ultimate goal is to assist in the development of an oceanic model to predict ocean thermal structure changes that have an important impact on environmental support for fleet operations. Our particular interest is in ocean prediction on time scales ranging from diurnal to seasonal periods. The suitability of the atmospheric forcing derived from the Fleet Numerical Oceanography Center analyses and models has been tested by comparison with the change in oceanic heat content from the North Pacific Experiment TRANSPAC monthly analyses (Elsberry, Gallacher and Garwood, 1979; Gallacher, Elsberry, and Garwood, 1979). An area along the southern boundary of the region was found to have excessive upward heat flux, such that no spring transition is predicted if the ocean model is provided the FNOC heat flux fields (Budd, 1980; Elsberry, Budd and Gallacher, 1980). A correction to the heat flux field has been derived for the spring transition periods but this correction needs to be tested during other seasons and years.

Publications: R. L. Elsberry, R. W. Garwood, Jr., "Numerical Ocean Prediction Models -- Goal for the 1980's," Bulletin American Meteorological Society, 61, #12, December 1980.

R. L. Elsberry, and R. W. Garwood, Jr., "First Generation Numerical Ocean Prediction Models -- Goal for the 1980's, NPS Technical Report, NPS63-79-007, 41 pp.

- Conference Presentations:
- R. L. Elsberry, P. C. Gallacher, and R. W. Garwood, Jr., "Prediction of NORPAX Anomalies with a One-Dimensional Mixed Layer Model," presented at International Union of Geophysics and Geodesy Symposium, Canberra, Australia, December 1979.
- R. L. Elsberry, P. C. Gallacher, and R. W. Garwood, Jr., "The Production of SST Anomalies Local Atmospheric Forcing," presented at Annual Fall Meeting of American Geophysical Union, San Francisco, CA, December 1979, abstract in EOS, 60, 860.
- R. L. Elsberry, B. W. Budd, P. C. Gallacher, and R. W. Garwood, Jr., "Prediction of Sea-Surface Temperature Anomalies Generated During Spring Transition," presented at Third Conference on Ocean-Atmosphere Interaction, Los Angeles, CA, January 1980, abstract in Bulletin American Meteorological Society, 60, 1244.
- R. W. Garwood, Jr., "Mixed Layer Modeling -- from Basic Research to Operational Forecasting," presented at Satellite Oceanography Workshop, Diamondhead, MI, 9-11, October 1979.
- Thesis Directed:
- B. W. Budd, "Prediction of the Spring Transition and Related Sea-Surface Temperature Anomalies," Master's Thesis, June 1980.

Title: Oceanic Thermal Response to Atmospheric Forcing

Investigators: Russell L. Elsberry, Professor of Meteorology, and Roland W. Garwood, Jr., Assistant Professor of Oceanography

Sponsor: Office of Naval Research

Objective: To understand through numerical model simulations and data analysis the role of atmospheric forcing in the dynamics of the upper layers of the ocean.

Summary: During the past few years we have demonstrated that a major fraction of the near-surface ocean thermal structure changes can be related to the diurnal and synoptic time-scale atmospheric forcing. An ocean circulation model with an embedded mixed layer has been developed (Adamec, Elsberry, Garwood and Haney, 1980) as a tool to better understand the three-dimensional oceanic response to strong forcing. The first application of this new tool has been to study the oceanic response to hurricane forcing. We have been able to simulate the basic differences in oceanic response to fast-moving versus slow-moving hurricanes.

Publications:

R. L. Elsberry, D. Adamec, R. W. Garwood, Jr., and R. L. Haney, "An Embedded Mixed Layer-Ocean Circulation Model," Dynamics of Atmospheres and Oceans, Submitted for publication.

R. L. Elsberry, R. W. Garwood, Jr., "Numerical Ocean Prediction Models -- Goal for the 1980's," Bulletin of American Meteorological Society, 61, #12, December 1980.

R. L. Elsberry, R. W. Garwood, Jr., "First Generation Numerical Ocean Prediction Models -- Goal for the 1980's," NPS Technical Report, NPS63-79-007, 1979, 41 pp.

R. W. Garwood, Jr., "Air-Sea Interaction and Dynamics of the Surface Mixed Layer," Rev. Geophys. Space Phys., 17, 1507-1524.

- Conference Presentations:**
- D. Adamec, R. L. Elsberry, R. L. Haney, and R. W. Garwood, Jr., "Coupling a Mixed Layer Model with a General Circulation Model," presented at 1979 AGU Fall Meeting, abstract in EOS, 60, 862.
- R. L. Elsberry, G. W. Garwood, Jr., and D. Adamec, "Numerical Simulation of the Effect of Surface Heating and Stratification upon an Ocean Surface Density Front," presented at Third Conference on Ocean-Atmosphere Interaction, Los Angeles, CA. January 1980, abstract in Bull. American Meteorological Society, 60, 1244.
- R. L. Elsberry, B. W. Budd, P. C. Gallacher and R. W. Garwood, Jr., 1980, "Prediction of Sea-Surface Temperature Anomalies Generated During Spring Transition," presented at Third Conference on Ocean-Atmosphere Interaction, Los Angeles, CA, January 1980, abstract in Bull. American Meteorological Society, 60, 1244.
- Thesis Directed:**
- R. Shook, "The One-Dimensionality of the Upper Ocean and the Role of Mixing and Advection During the POLE Experiment, Master's Thesis, 1980.

Title: The Role of the Ocean in Extratropical Cyclone Evolution

Investigator: Russell L. Elsberry, Professor of Meteorology

Sponsor: NPS Foundation Research Program

Objective: The purpose of this research is to improve our understanding of the role of the air-sea fluxes in the extratropical cyclone evolution. A study of the cyclone and its environment will be carried out in a numerical model by systematically introducing the air-sea fluxes. Then the air-sea fluxes predicted in the atmospheric model will be used to drive an ocean model to determine the effect on the sea-surface temperature. The purpose will be to see if the ocean thermal structure changes are large enough to affect the air-sea fluxes in this or a subsequent storm. Finally, the atmosphere and ocean models will be run simultaneously to establish feedback mechanisms.

Summary: The approach in the atmospheric experiments is to systematically add or subtract physical processes in the numerical model. The resulting effect on the development, maintenance and movement of the extratropical cyclones over the ocean is being studied from the history files of the computer runs. It appears that the wavelength of the cyclones in the diabatic model runs is only half that found in the diabatic model results. Further results are expected from diagnostic interpretations of the atmospheric model results. The ocean model runs have not yet been completed. Future experiments will probably involve the use of a finer-resolution atmospheric model to study cyclogenesis in polar air streams over the ocean and over land.

Conference Presentations: S. A. Sandgathe and R. L. Elsberry, "An Unsolved Problem-What Factors Produce Ocean Cyclogenesis,". Paper accepted for Symposium on Current Problems of Weather Prediction, Vienna, Austria, June 1981.

R. L. Elsberry and S. A. Sandgathe, "The Effect of the Ocean on Medium Range Forecasting,". Paper accepted for Symposium on Current Problems of Weather Prediction, Vienna, Austria, June 1981.

Thesis  
Directed:

S. A. Sandgathe, Ph.D. Thesis, in preparation.

Title: Tropical Cyclone Studies

Investigator: Russell L. Elsberry, Professor of Meteorology

Sponsor: Naval Air Systems Command

Objective: Improvement of numerical predictions of tropical cyclone tracks in the Pacific Ocean.

Summary: A cooperative effort to develop an operational numerical forecast model for tropical cyclones in the North Pacific was begun in 1975. Recent work on this project has focused on development of statistical post-processing techniques for removing systematic errors in the track forecasts. Elsberry and Frill (1979, 1980) have shown that the statistical technique results in a marked improvement in forecast skill of the Tropical Cyclone Model. A recent masters thesis by Gilchrist (1980) demonstrated that a similar approach resulted in significant reduction in forecast errors from the HATRACK technique. Using similar ideas, Peterson developed an improved method for the adjustment of the analog storm tracks in the TYAN 78 technique. Work is in progress to develop a similar post-processing technique for the new nested two-way interaction tropical cyclone prediction model. A paper summarizing the official tropical cyclone track forecast errors in the eastern North Pacific after normalization by a climatology-persistence forecast has been submitted for publication.

Publications: R. L. Elsberry, and D. R. Frill, "Statistical Post-Processing of Dynamical Tropical Cyclone Model Track Forecasts," Monthly Weather Review, 108, #8, August 1980, 1219-1225.  
R. L. Elsberry, and W. J. Thompson and R. R. Read, "An Analysis of Eastern North Pacific Tropical Cyclone Forecast Errors," submitted to Monthly Weather Review.

Conference  
Presentations: R. L. Elsberry, and D. R. Frill, "Statistical Adjustment of Dynamical Tropical Cyclone Model Track Forecasts," presented at Tropical Cyclone Conference, Perth, Australia, November 1979.

Theses  
Directed: R. C. Gilchrist, "Statistical Adjustment of the HATRACK Typhoon Track Forecasting Model," Master's Thesis, June 1980.

K. A. Peterson, "Adjustment of Analog Tracks Using Statical Regression Equations," Master's Thesis, June 1980.

Title: Numerical Modeling of Large-Scale Ocean Variability

Investigator: Robert L. Haney, Associate Professor Meteorology

Sponsor: Office of Naval Research

Objective: To continually develop and improve a numerical model of the North Pacific Ocean and to use the model to identify processes responsible for the formation and evolution of large-scale thermal anomalies in the ocean.

Summary: During the period of this research, considerable attention was given to a study of the climatological distribution of synoptic storm activity over the North Pacific Ocean using 6-hourly surface wind analyses obtained from FNOC. This wind data will be used to drive a new embedded mixed layer ocean circulation model in a 10 year hindcast (1969-78) of the currents and temperature structure in the Central mid-latitude North Pacific Ocean.

Publications: R. L. Haney, "A Numerical Case Study of the Development of Large Scale Thermal Anomalies in the Central North Pacific Ocean," J. Phys. Oceanogr., 10 (1980), p. 541-556.  
R. L. Haney, M. S. Risch and G. C. Heise, "Wind Forcing due to Synoptic Storm Activity Over the North Pacific Ocean," submitted to Atmosphere-Ocean.  
D. Adamec, and R. L. Elsberry, R. W. Garwood Jr., and R. L. Haney, "An Embedded Mixed Layer-Ocean Circulation Model," submitted to Dyn. Atmos. Oceans.

Conference Presentations: R. L. Haney, "A Numerical Study of the Development of Large-Scale Thermal Anomalies in the Central North Pacific Ocean," XVII General Assembly of the IUGG, Canberra, Australia, 2-15 December 1979.

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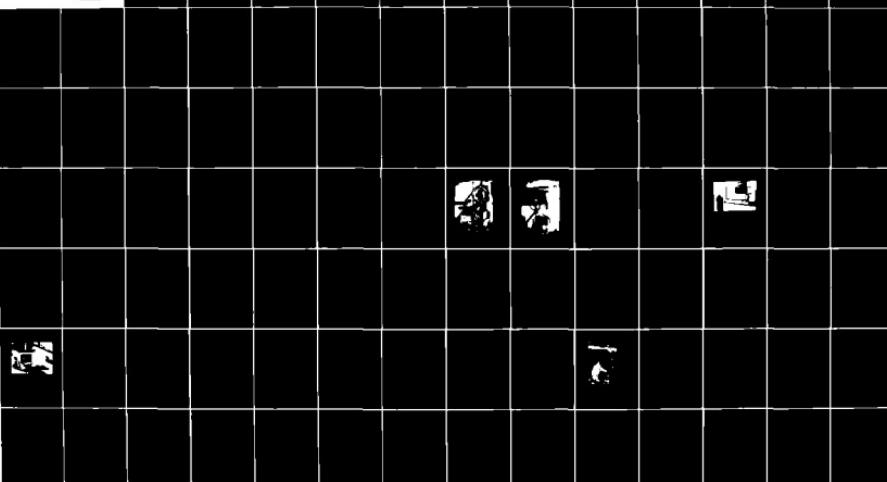
A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH PROGRAM. (U)

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D. Adamec, R. L. Elsberry, R. L. Haney and  
R. W. Garwood, Jr., "Coupling a Mixed-Layer  
Model with a General Circulation Model,"  
Fall Annual Meeting of the AGU, San Francisco,  
3-7 December 1979.

R. L. Haney, and M. S. Risch, "On the Pumping  
and Mixing of the Ocean by Synoptic Storm  
Activity," AMS Third Conference on Air Sea  
Interaction, Los Angeles, 30 January - 1  
February 1980.

Title: Tropical Large-Scale Ocean-Atmosphere Ocean Coupling

Investigators: Ka Ming Lau, Adjunct Assistant Professor of Meteorology, Chih-Pei Chang, Associate Professor of Meteorology

Sponsor: National Science Foundation

Objective: To study the mutual influence of tropical large-scale atmospheric circulation on SST and oceanic mixed layer processes over the time scales ranging from seasonal to inter-annual.

Summary: The role of the Hadley-type and Walker-type circulation contributing to a feedback relationship with oceanic circulation, upwelling and turbulent mixing in the upper strata of the ocean are investigated using a simple domain-averaged numerical model. Various physical mechanisms in the coupled ocean-atmosphere system are identified in a climatic feedback process leading to observed large-scale teleconnections e.g. the El Nino and the Southern Oscillation phenomena. Results showed that Hadley cell and Walker cell plays important but different roles in the interaction with oceanic processes.

Publications:

- K. M. Lau, "A Numerical Study of Tropical Large-Scale Air-Sea Coupling," J. Atmos. Sci., 36, 8, 1467-1489.
- K. M. Lau, "Climatic Feedback Mechanisms in the Tropical Pacific," Ocean Modeling, 28.
- K. M. Lau, "Oscillation in a Simple Equatorial Climate System," J. Atmos. Sci., (in press).
- C. P. Chang, and K. M. Lau, "Oscillations of Planetary Scale Motions During Winter Monsoons," submitted to Monthly Weather Review.

**Title:** Application of Model Output Statistics to Forecasting Air/Ocean Parameters

**Investigators:** R. J. Renard Professor of Meteorology, and W. van der Bijl, Associate Professor of Meteorology.

**Sponsor:** Environmental Prediction Research Facility

**Objective:** To improve the accuracy of forecasting operationally important air/ocean parameters over the ocean areas using the methods of model output statistics applied to Fleet Numerical Oceanography Center (FNOC) model output data. Work in this project represents a continuation of effort begun in the Marine Fog Forecasting Project (NAVAIRSYSCOM).

**Summary:** Effort is nearly complete on a prototype model output statistics (MOS) program to specify, by stepwise selection multiple linear regression, marine fog probability in the summer season for 0-, 24- and 48-hr forecast intervals, using dependent and independent data sets and FNOC model output parameters from June 1976 and 1977, and July and August 1979 for the area 20.ON-60N, North Pacific Ocean. Categorical fog/no fog estimates are also derived from the regression determined probabilities. Threat, Heidke skill percentage correct and P-score verifications indicate accuracy excelling climatology and an operational fog probability forecast scheme, called FTER, operationally run at FNOC. Similar programs were also developed to probabilistically and categorically estimate summer season horizontal visibility at sea to 48 hours. The categorical visibility study has been completed; the probabilistic visibility study which also generates categorical visibilities, will be completed in early FY 81. Tentative conclusions indicate the relative excellence of the probabilistic approach and the necessary limitations to three visibility categories (0 to < 2km) (2km to < 10km) ( $\geq$  10 km) for operational utility.

**Publications:** P. G. Yavorsky and R. J. Renard, "Experiments Concerning Categorical Forecasts of Open-Ocean Visibility Using Model Output Statistics," NPS Tech. Report, NPS63-80-002, June 1980, 87 pp.

R. J. Renard, W. J. Thompson and M. C. Koziara, "Development of a Statistical Model to Specify Marine Fog Probability Using Numerically-Derived Model Output Statistics," pp 13-18 in Conference Proceedings of Eighth Conference on Weather Analysis and Forecasting, 10-13, June 1980, Denver, CO; published in American Meteorological Society, Boston, MA, 500 pp. Abstract of conference presentation in BAMS, Vol 61, #3, March 1980, p. 273.

**Conference Presentations:** R. J. Renard, P. G. Yavorsky, W. T. Aldinger and W. van der Bijl, "Visibility Estimates for the Open Ocean Summer Season Using Model Output Statistics," American Geophysical Union Spring Meeting, Toronto, Canada, 22-27 May 1980 (abstract in EOS Transactions, AGU, Vol. 61, #17, 22 April 1980, p. 241).

R. J. Renard, W. J. Thompson and M. C. Koziara: "Development of a Statistical Model to Specify Marine Fog Probability Using Numerically-Derived Model Output Statistics", pp 13-18 in Conference Proceedings of Eighth Conference on Weather Analysis and Forecasting 10-13 June 1980, Denver CO; Published in American Meteorological Society, Boston, MA, 500 pp. (abstract of conference presentation in BAMS, Vol. 61, #3, March 1980, p. 273.

**Thesis Directed:** W. T. Aldinger, "Experiments in Estimating Open Ocean Visibilities Using Model Output Statistics," Master's Thesis, December 1979, 81 pp.

P. G. Yavorsky, "Experiments Concerning Categorical Forecasts of Open Ocean Visibility Using Model Output Statistics," Master's Thesis, June 1980, 87 pp.

**Title:** Marine Fog Forecasting

**Investigators:** Robert J. Renard, Professor of Meteorology,  
Dale F. Leipper, and Glenn H. Jung,  
Professors of Oceanography.

**Sponsor:** Naval Air Systems Command

**Objective:** To improve the analysis and forecasting of  
marine fog over the open ocean and coastal  
areas.

**Summary:** Observations of fog at sea are obtained,  
analyzed, and statistically related to  
other parameters representing the state of  
the atmosphere and ocean. Programs for  
statistical, diagnostic and prognostic  
specification of marine fog are being  
developed. Improvement of regional area  
fog forecasting is being sought using a fog  
sequential development model and fore-  
casting indices. Since the research began  
in 1971, it has been directed toward re-  
ducing the unfavorable impact of marine fog  
on Naval operations; contributions toward  
this have been made through increased  
knowledge of fog climatology, improved  
fog analysis and prediction, and consi-  
deration of processes involved in fog  
formation and dissipation. In FY 80  
satellite data from GOES West has been  
tested for use in specifying marine fog  
areas; the coastal version of the six-  
stage sequential development model is  
being extended to California coastal areas  
beyond Monterey, and an open ocean model  
is being explored for the central Gulf  
of Alaska.

**Conference Presentations:** D. F. Leipper, "Day-to-Day and Place-to  
Place Changes in Low Level Atmospheric  
Temperature Structure," American Meteoro-  
logical Society (AMS) Conference on Coastal  
Meteorology, Los Angeles, CA, 30 January -  
1 February, 1980; Abstract in Bulletin of  
the AMS(BAMS) 60 (1) p. 1270, and in Con-  
ference Proceedings.

D. F. Leipper, "Coastal Fog Forecasting at Monterey, CA, an Open-Ended Objective, 3 - to 6 - Day Approach," AMS Eighth Conference on Weather Forecasting and Analysis, Denver, CO, 10-13 June 1980; Abstract in BAMS 61 (3) p. 282 and in Conference Proceedings.

R. J. Renard, W. T. Aldinger, P. G. Yavorsky and W. van der Bijl, "Visibility Estimates for the Open Ocean Summer Season Using Model Output Statistics," American Geophysical Union Spring Meeting, Toronto, Canada, 22-27 May 1980; Abstract in EOS (61) p. 241.

R. J. Renard, M. C. Koziara and W. J. Thompson, "Development of a Statistical Model to Specify Marine Fog Probability Using Numerically Derived Model Output Parameters," AMS Eighth Conference on Weather Forecasting and Analysis, Denver, CO, 10-13 June 1980. Abstract in BAMS 61 p. 272.

Theses  
Directed:

W. T. Aldinger, "Experiments on Estimating Open Ocean Visibilities Using Model Output Statistics," Master's Thesis, December 1979 (R. J. Renard, Advisor).

P. G. Yavorsky, "Experiments Concerning Categorical Forecasts of Open-Ocean Visibility Using Model Output Statistics," Master's Thesis, June 1980 (R. J. Renard, Advisor).

R. L. Clark, "Open Ocean Marine Fog Description and Development Model; Gulf of Alaska," Master's Thesis (In Progress) (G. H. Jung, Advisor).

**Title:** Mesoscale Atmospheric Events--Antarctica

**Investigator:** R. J. Renard, Professor of Meteorology

**Sponsor:** National Science Foundation

**Objectives:** It is proposed to diagnose mesoscale atmospheric events and their relation to synoptic scale circulations during the Austral summer period over an area surrounding McMurdo, Antarctica, through the analysis of observations taken by weather satellites (visual and infrared), specially-configurated aircraft, automatic weather stations and conventional means. The immediate goal is to identify the meso-synoptic scale processes relating to operationally significant weather in the McMurdo area, demonstrating thereby the unique combined use of the aforementioned data sources. Particular attention will be given to katabatic winds, poleward directed moisture intrusions and regionally-induced thermal/circulation patterns. The longer term goal is to model mesoscale systems associated with significant weather-producing synoptic-scale circulations over a permanent ice/snow covered region of variable elevation and to show the applicability of weather satellite observations, with or without a supporting net of closely spaced stations, to monitor such atmospheric events. Extension of the mesoscale network to areas other than McMurdo and seasons other than summer is dependent on achieving the immediate goals of the proposal. Project will terminate 31 May 1981.

**Summary:** Work this past year was again concentrated on special Antarctic data sources. The data collected by the Airborne Research Data System (ARDS) during the January 1978 Radio Echo Sounding (RES) missions flown in the Antarctic by an LC-130R aircraft of the U.S. Navy Antarctic Development Squadron Six (VXE-6) were analyzed. Thirteen ARDS missions were flown, ten of which were briefly documented. The remaining three flights were analyzed in greater depth. Wind direction and speed, temperature, dew-point and frost-point data were examined and interrelated in varying degrees of detail. For the three

flights, calculations of heights of 400 mb and 500 mb pressure levels were carried out using specially reduced altimetry from the Scott Polar Research Institute. The in-depth analysis also consists of comparisons of ARDS data with the operational analyses of Naval Support Force Antarctica, McMurdo Station, Antarctica; Fleet Numerical Oceanography Center, Monterey, CA; and the National Meteorological Center, Washington, DC. ARDS research generated a thesis (see below) and will result in a technical report in FY 81. In another phase of the Antarctic research, 1979 data from seven of the second generation of Stanford University Automatic Weather Stations (AWS II), placed on the Antarctic continent and adjacent ice shelves, were partially analyzed. Each remote station records wind (direction and speed), pressure and temperature data, transmitting same to NIMBUS VI in 1979. The AWS II analysis will help to determine credibility of the remote sensed data for diagnosing Antarctic circulations and establish usefulness of the data to the research/operational mission of the National Science Foundation. Completion of this task is expected in early FY 81.

Thesis  
Directed:

B. P. Smith, "Descriptive Analysis of January 1978 Antarctic RES Missions Flown by ARDS-Configurated LC-130 Aircraft," September 1980, 157 pp.

Title: Numerical Prediction Model Development

Investigator: R. T. Williams, Professor of Meteorology

Sponsor: Naval Air Systems Command

Objective: To develop and test procedures for global and regional prediction.

Summary: The proper modeling of air flow over a narrow high mountain range is a major problem in numerical weather prediction. The numerical model that was developed by Hayes and Williams (1977) is being used to study the effect of mountain configurations on cyclogenesis.

The finite element method has special promise for limited area forecasting since the size and arrangement of the elements can be varied. Various formulations were analyzed and tested in linearized form. Two new arrangements were proposed and compared with the other schemes.

Numerical experiments were carried out with a splitting scheme which uses short time-steps for the gravity wave terms and longer steps for advective terms. This method will be especially useful for finite element prediction models.

Publications:

R. T. Williams, "On the Formulation of Finite Element Prediction Models," accepted by Monthly Weather Review, 109, 1981.

R. T. Williams and O. C. Zienkiewicz, "Improved Finite Element Forms for the Shallow Water Wave Equations," accepted by Numerical Methods in Fluids, 1, 1981.

R. T. Williams and A. L. Schoenstadt, "Formulation of Efficient Finite Element Prediction Models," NPS Technical Report, NPS63-80-001, 1980, 37 pp.

Conference  
Presentation:

R. T. Williams, "An Efficient Time-Split  
Integration Method for the Shallow Water  
Equations," Presented at Fall Meeting of  
American Geophysical Union, San Francisco,  
abstract published in Transactions, Ameri-  
can Geophysical Union, 60, p. 840.

Title: Numerical Simulation of Fronts Over Eastern Asia

Investigators: R. T. Williams, Professor of Meteorology and L. Chou, Instructor of Meteorology

Sponsor: NPS Foundation Research Program

Objective: The objective of this research is to predict the structure of slow moving fronts associated with the early summer monsoon trough over eastern Asia, and to predict the spatial variation of the structure along the frontal zone.

Summary: This research uses an improved version of the numerical model which was developed by Cornelius, Glevy and Williams (1975). In this formulation, frontogenesis is forced by a horizontal wind field which contains deformation. The model includes a moisture prediction equation and condensation heating. Steady state solutions are achieved with the addition of horizontal and vertical diffusions of momentum, temperature and moisture. The new numerical model uses a staggered grid and stretched coordinates to improve accuracy and efficiency. A coordinate transformation is also used to allow surface frontal motion.

The numerical solutions show that condensation heating causes a much sharper front at upper levels when compared with dry experiments. However, surface frontal motion has very little effect on frontal structure when compared to atmospheric fronts. The numerical experiments show that the characteristics of the frontal structure are altered with changing Coriolis parameter,  $f$ . With a mid-latitude value of  $f$  under a typical potential temperature sounding, the frontal zone reveals strong horizontal temperature gradient and vertical tilt, which resembles a typical mid-latitude frontal zone. With a low-latitude value of  $f$  and a low-latitude potential temperature sounding, the frontal zone is changed to a state with weaker horizontal temperature gradient and

very little tilt in vertical, which resembles  
the inter-tropical convergence zone.

Publications: R. T. Williams, L. Chou, and C. J. Cornelius,  
submitted to Journal of the Atmospheric Sciences.

L. Chou and R. T. Williams, "Effects of Con-  
densation and Surface Motion on the Struc-  
ture of Steady-State Fronts," presented at  
Fall Meeting of American Geophysical Union,  
San Francisco, CA, abstract published in  
Transactions, American Geophysical Union,  
60, p. 840.

## DEPARTMENT OF AERONAUTICS

The research effort of the Aeronautics faculty covers a broad range of aeronautical engineering disciplines with special emphasis on Naval aviation problems.

### AIRCRAFT COMBAT SURVIVABILITY

Professor Bell is continuing his research in aircraft combat survivability with support from the Naval Air Systems Command and the Joint Technical Coordinating Group for Aircraft Survivability (JTCG/AS). Recent projects include a study of the survivability features on past, present, and future military aircraft; a study of the threat to the S-3 aircraft and an assessment of its detectability; a proposed program for the operational testing and evaluation of aircraft for survivability; development of a computer graphics capability for use in survivability assessment; a study of the organizations and programs for cruise missile survivability; and studies of several endgame programs for computing probability of aircraft kill by missile warheads.

### VSTOL AERODYNAMICS

Professor Bell is attempting to gain insight into VSTOL jet reaction flow field modeling in order to increase the predictive capability of such VSTOL related flow phenomena as suckdown, hot gas ingestion and entrainment. Development of a prototype vorticity meter is the current objective.

### INVESTIGATION OF THE POTENTIAL FOR MINGLING TANDEMLY EMITTED PARALLEL JETS

Professor Bell has completed preliminary investigation on the feasibility of deliberately forcing interference, at small scale, of tandem cold jets in order to establish whether adequate flow mechanisms exist to ensure efficient mingling of the jets. A pilot program with two 1-inch diameter jets has been assembled with which to obtain experience and derive parameters pertinent to a larger set up.

### STABILIZATION OF GASEOUS DISCHARGES

Professor Biblarz has continued his studies on defining practical aerodynamic means for stabilizing discharges of interest for electrical lasers and other applications. Tests were made to determine the effects of intense, low-frequency turbulence and comparisons were made on discharge geometries. Also, a new electrode configuration was designed and tested.

## STUDY OF BASIC MECHANISMS THAT LEAD TO ARCING

Professors Biblarz and Schwirzke are studying the basic mechanisms that lead to arcing in laser discharges and developing a discharge model which will aid in the prediction of discharge conditions. Work is both analytical and experimental.

## ETD POWER GENERATION STUDY

Professors Gawain and Biblarz have analyzed an ETD power generator with full allowance for the effects of compressibility. They have also introduced the concept of a two-fluid ejector into the study. Initial calculations indicate that the performance of an all-steam system is not satisfactory but that a two-fluid system appears promising.

## LASER DOPPLER ANEMOMETRY INVESTIGATIONS

Professor Collins has developed a two-color laser doppler anemometry (LDA) for measurement in V/STOL and turbomachinery applications. He has made extensive measurements in a jet excited by an oscillatory vane in the potential core. All the equipment needed for two-color measurements has been assembled. The system with the computer data reduction equipment is now being constructed and tested.

Professor Collins is also conducting research on the application of multivariable control concepts to engine and flight technology.

## LASER BEAM PROPAGATION

Professors Fuhs and Vanderplaats are determining the degradation of laser propagation due to turbulent boundary layer and turbulent shear layers; propagation wavelength is in the visible or near UV.

## EXCIMER LASERS

Professor Fuhs is continuing his investigation on the transient index of refraction in an e-beam pumped XeF excimer laser.

## NONDESTRUCTIVE TESTING (NDT)

Professor Fuhs is determining the suitability of holographic and speckle nondestructive tests as a means of locating weld flaws in piping and cracks in plates.

Real time holography is used to obtain fringe patterns. The holography system has been assembled. Real time holograms were made of vibrating plates with and without flaws or cracks. Using speckle metrology techniques, which include generation of Young's fringes, surface displacements in linear and rotation were measured.

#### GUN LAUNCHED RAMJET GUIDED MISSILE

Professor Fuhs screened various Navy missions which are appropriate for a gun launched ramjet guided projectile. A ramjet guided projectile is being designed for the antiship missile defense (ASMD) mission. Other missions are also being examined.

#### AIRBORNE LASER TURRET

Professor Fuhs investigated experimentally the efficacy of flow control using suction in the fairing for a laser turret. A laser turret with 18-inch diameter and fairing was built and mounted in the Naval Postgraduate School smoke tunnel.

#### LAMINAR FLOW LASER TURRETS

Professor Fuhs investigated far field diffraction from an array of apertures of small size. In future investigation, distribution of laser power to multiple turrets will be considered.

#### PROBE FOR PRESSURE ALTITUDE FUZE

Professor Fuhs developed a probe which senses ambient pressure from a supersonic projectile or missile. This probe was built and tested in the Naval Postgraduate School supersonic wind tunnel.

#### COMBAT SYSTEMS AND SHIP ARRANGEMENT

Professor Fuhs is continuing his study to determine quantitative figure of merit for ship arrangements as related to combat system.

#### ICEBERG UTILIZATION FOR FRESH WATER PRODUCTION

Professors Fuhs and Stolfi after completing their experiments have determined the rate of regression of fresh-water ice subjected to turbulent flow of sea water. In addition, they developed an analytical model which allows prediction of the ice melting rate and heat transfer rates.

#### PIPE FLOW STABILITY PROBLEM

Professor Gawain has reformulated the classical unsolved problem of the hydrodynamic stability of pipe flow and has completed the analytical solution; however, extensive numerical calculations still remain to be carried out.

#### SYSTEM SAFETY SOFTWARE

Professor Layton completed his investigation on the techniques for conducting system safety software analyses. In his investigation, it was found that techniques similar to those employed in hardware analyses for system safety were usable and that the connection between hardware and software analysis is enhanced by the fact that there is no software safety problem unless hardware is affected.

#### AIRCRAFT FATIGUE STUDIES

Professor Lindsey is developing improved methods of aircraft fatigue life prediction using data from fatigue monitoring devices currently being flight tested. This work also involves microprocessor technology, photelasticity, finite element numerical analysis and analytical methods, all of which are yielding results.

#### ELECTROHYDRODYNAMIC CONTROL OF FUEL INJECTION IN AIRCRAFT ENGINES

Professors Miller and Biblarz are doing preliminary investigation of the feasibility and practicality of controlling fuel injector spray characteristics by means of electrohydrodynamic spraying in an actual engine combustion system. A systematic test series of the effect with various fuels is in progress.

#### SOLID PROPELLANT COMBUSTION

Professor Netzer has continued his study of the combustion of composite solid propellant which was initiated under NSS Foundation Research sponsorship. The immediate goal of the study is to evaluate the relative advantages and disadvantages of different experimental techniques for obtaining two-phase flow characteristics within the combustion environment of a solid propellant grain.

## SOLID PROPELLANT ROCKET MOTORS

Professor Netzer initiated a detailed and systematic determination of the effects of propellant composition and motor operating environment on the behavior of metallic particulates within solid propellant rocket motors. Holographic, high speed motion picture, and scattered laser power spectra experiments were designed and appropriate hardware were fabricated. Six composite propellants were studied using high speed motion pictures of stand burners and scanning electron microscopy of post fire residues.

## AIR QUALITY ASSESSMENT MODEL FOR NAVAL AIR OPERATIONS

Professor Netzer has continued his research work in determining the emission levels and air quality effects from Naval Air Station aircraft operations and test cells. The air quality assessment computer model has been developed for Naval air operations and validation efforts have been conducted at NSA, Miramar, CA.

## TURBOJET TEST CELL AERODYNAMICS AND EMISSION LEVELS

Professor Netzer has continued to work on computer models for the flow fields in turbojet test cells. Model prediction for pressure and velocity distributions have been found to agree reasonably well with data obtained from tests at NSA, Alameda CA.

Initial testing has also been completed using a subscale test cell to determine the effects of smoke suppressant fuel additives on the particulates emitted from the engine and test cell.

## SOLID FUEL RAMJET COMBUSTION

Professor Netzer has continued the development of a computer simulation of the combustion process. Radiative heat transfer has been added to the finite-difference computer code. Initial results appear to agree with experimental data.

Also, in another study he has found the near-wall turbulence intensity in non-reacting flows to correlate with the fuel regression pattern in reacting flow for various combustor geometries.

## VSTOL PROPULSION PROBLEMS

Professor Platzer investigated the flow phenomena in V/STOL aircraft propulsion systems and performed V/STOL aircraft concept feasibility studies. A new jet excitation mechanism

has been identified which increases secondary flow entrainment in thrust augmenting ejectors without impairing nozzle efficiency. A patent application is currently being processed. Also, the analysis of unsteady supersonic cascade flows has been continued.

#### AIRCRAFT FLIGHT PARAMETER IDENTIFICATION

Professor Schmidt obtained a baseline set of flight time history data for contemporary Navy fighter aircraft (F-14). He analyzed these data using the modified maximum likelihood estimation (MMLE) technique and provided instruction on use of the MMLE technique to the Naval Air Development Center.

#### FLIGHT MECHANICS

Professor Schmidt conducted an on-site graduate course (NPS accredited) in flight mechanics to NASA engineers. In addition, he participated in a Joint Navy-NASA high angle of attack flight research program using the F-14 aircraft. He modified the digital computer code on the flight simulator to accommodate flight attitudes above sixty degrees for stall/spin research. Also, he conducted studies on the F-14 wing rock behavior.

#### APPLIED RESEARCH IN ENGINEERING TECHNOLOGY

Professor Schmidt assumed the position of Acting Assistant for Engineering Technology in the Office of the Assistant Secretary of the Navy (Research, Engineering and Systems). His duties included administering research contract reviews, visiting laboratory facilities and assisting in policy establishment for Navy 6.1, 6.2 and 6.3A research on aircraft, missile, ship, submarine and boat platforms in the disciplines of fluid mechanics, propulsion and structures.

#### MULTI-STAGE COMPRESSOR STUDIES

Professor Shreeve has continued his investigation of the flow characteristics in a low speed three-stage axial compressor, with special emphasis on tip clearance effects. The first phase of this study, conducted by Professor Shreeve, involved reblading and instrumenting the compressor. The second phase also conducted by Professor Shreeve, involved completing the reblading and carrying out baseline measurements of the performance and internal flow for the newly designed "symmetrical" bladings.

## TRANSONIC COMPRESSOR MODEL

Professor Shreeve developed a small transonic axial air compressor model and established methods of measuring the performance and flow behavior in small machines. Modifications of the test rig for flutter were studied in the interim.

## TRANSONIC COMPRESSOR INVESTIGATION

Professor Shreeve has continued his work to determine by measurement the behavior of the flow through transonic axial compressor bladings in order to appraise and improve predictive analytical models for steady and unsteady effects.

In earlier phases of the program, a single stage axial compressor and test rig were designed, built, installed and tested to transonic flow conditions. New measurements techniques were developed and applied to define the internal flow field. Emphasis was put on computer techniques for acquiring and processing both steady state and high speed data and this phase was recently completed. Successful tests were made of small transonic cascade model of the rotor tip flow and a major success was the introduction of a straightforward general method for representing the calibration of flow probes.

## AXIAL COMPRESSOR FLOW FIELDS

Professor Shreeve is continuing his study of flow fields in axial compressors to obtain detailed measurements against which new computer codes can be verified.

The complete definition of the flow field leaving a high speed single stage axial rotor in a rotor-first arrangement is being attempted using a new measurement technique. Two semiconductor probes of simple geometry are used together with "synchronized sampling" to measure the periodic component of the velocity (vector) field. To date, the distribution of flow yaw angle on the annulus centerline has been measured in the compressor using a single probe, and the first data were obtained from the compressor with a system of two probes. Multiple techniques for deriving the velocity vector from the two probe system have been devised and the required software has been written. Tests to obtain rotor exit velocity map data at high rotational speeds will resume shortly.

Title: Aircraft Combat Survivability Studies

Investigator: Robert E. Ball, Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To provide technical support to AIR-5184, Combat Survivability Branch, Naval Air Systems Command, The following projects contribute to the technology/methodology base in several areas of survivability:

- a) Mission-Threat Analysis and Susceptibility Assessment for the S-3 Aircraft.
- b) A Study of Survivability Features on Past and Current Aircraft.
- c) OT&E for Survivability.
- d) Survivability Assessment Using Interactive Graphics
- e) Cruise Missile Survivability
- f) Vulnerability/Endgame Assessment.

Summary: The S-3 aircraft provides organic, airborne ASW support to the U.S. Carrier Battle Group. The versatile sensor capabilities and the performance characteristics of the S-3 also allow additional mission opportunities that are responsive to the total threat environment of the aircraft carrier. This study examined the total S-3 operating environment to determine those specific threats to the S-3 that can deny or degrade mission accomplishment. The hostility of the environment is determined as a function of:

- a) the mission requirements of the aircraft,
- b) the detectable aircraft observables, and
- c) the intentions and capabilities of the threat to either physically damage the aircraft or to prevent it from using its sensors.

Encounter scenarios were developed as a function of the current sensor capabilities and operational tasking of the S-3 and the potential threat weapon systems. Concepts for increasing the probability of mission accomplishment were also examined.

This work presents the evolution of survivability technology of combat aircraft from World War II to the present. Various historical examples of combat aircraft are described in order to illustrate their survivability enhancement features or lack of them to trace the development of survivability technology driven by combat experience and losses, and to study the impact of survivability on mission effectiveness. Both helicopters and fixed-wing aircraft are examined with examples from World War II, the Korean War, the French-Algerian War, the Southeast Asia Conflict, and the Yom Kippur War. The current state of technology is presented by depicting in detail the vulnerability reduction and susceptibility reduction features of seven fixed-wing aircraft and four helicopters.

The increasing cost and complexity of naval air weapons systems, coupled with increasing intensification of the threats that they face in a combat environment, have generated renewed attention to the requirement to design combat survivability into these systems. With the specification of survivability requirements in system procurement contracts has come the necessity to operationally test and evaluate the effectiveness of the survivability features and their impact on mission attainment. Realistic Operational Test and Evaluation (OT&E) for survivability poses unique problems for the individual who must plan, direct, or assess the OT&E program for a naval air weapons system. Techniques were developed in this study to integrate OT&E for survivability into the overall test program. These techniques identify the Essential Elements of Analysis and the Critical Issues for survivability. Additionally, an overall survivability measure the Survival Rate,  $S$ , is defined in conjunction with the definition of an overall Mission Attainment Measure. A rationale is presented for deriving  $S$  directly from test results and a method for computing  $S$  using stochastic modelling is also given.

Several programs that simulate surface-to-air missile/aircraft encounters were evaluated for possible use at the Naval Post-graduate School in studies of missile lethality and aircraft survivability using interactive graphics. The Air Force Aero-nautics Systems Division model, Missile Intercept Capability Evaluation (MICE-II) was selected for adaptation to the NPS IBM 360/67 computer. Because this model was written in Extended FORTRAN IV for a CDC 6600 computer system, MICE II had to be modified to make it compatible with the IBM system. A detailed user's manual was written for MICE II as installed at NPS. This manual contains a brief description of the program and an explanation of its features and capabilities. The user's manual was designed to assist students in preparing the input data and interpreting the output. Another work contains a survey of the capabilities and limitations of the NPS Tektronix 4081 and shows it to be a very versatile and capable graphics computer when applied to the missile/aircraft encounter display. Its 64 K-byte memory size dictates the 4081 be used in conjunction with the NPS IBM 360/67 to handle the large matrix operations which are present in programs such as those currently available through the Navy and Air Force. An easy-to-follow guide with examples on the basics of how to use the 4081 is provided. This effort will be continued.

This effort will be completed in the Fall Quarter, 1980. The Endgame Computer programs ATTACK and SCAN have been obtained from NWC and PMTC respectively. They have been made operational on the NPS IBM 360/67. A simple sample target was developed that could be easily modeled in both programs in order to evaluate the similarities and difference between the two programs.

Theses  
Directed:

M. A. Boies, "The Evolution of Survivability Technology of Combat Aircraft from World War II to the Present," Master's Thesis, March 1980.

M. R. Etheridge, Jr., "Operational Test and Evaluation for Survivability of Naval Air Weapons Systems," Master's Thesis, June 1980.

P. F. Coste, "A Survey of Surface-to-Air Missile Computer Models and Adaptation of the Missile Intercept Capability Evaluation (MICE-II) Model for Use at the Naval Post-graduate School," Master's Thesis, June 1980.

R. S. Wise, "Initial Examination of Application of the Tektronix 4081 Graphics Computer to Display of a Missile Versus Aircraft Encounter," Master's Thesis, June 1980.

Title: Investigation of the Potential for Mingling  
Tandemly Emitted Parallel Jets

Investigator: R. W. Bell, Professor of Aeronautics

Sponsor: Naval Weapons Center

Objective: In cruise mode, the cold (engine bypass) forward exhaust jet of the Harrier aircraft's Pegasus engine trails into the neighborhood of the hot rear turbojet exhaust. Efficient mingling of these exhausts might advantageously affect IR signature. Preliminary assessment of feasibility is to be examined by deliberately forcing interference, at small scale, of tandem cold jets in order to establish whether adequate flow mechanisms exist for the purpose.

Summary: A pilot program with two 1-inch diameter jets has been assembled with which to obtain experience and derive parameters pertinent to a larger setup, if desirable.

Title: V/STOL Aerodynamics

Investigators: R. W. Bell, Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: This project is attempting to gain insight into VSTOL jet reaction flow field modeling in order to increase the predictive capability of such VSTOL related flow phenomena as suck-down, hot gas ingestion and entrainment.

Summary: Since vorticity apparently plays the major role in characterization of the jet trajectory in a cross-flow, and hence of the jet interference effects relative to both the airframe and the ground in a VSTOL context, experimental procedures are being evolved to study the jet from direct measurements of vorticity, and to determine the effects on the jet of interfering with it or modifying it both by changing its velocity profile and by introducing swirl components into it. Development of a prototype vorticity meter is the current objective.

Title: Aerodynamic Stabilization of Gaseous Discharges

Investigators: Oscar Biblarz, Associate Professor of Aero-nautics and J. L. Barto, LCDR, Instructor, U. S. Naval Academy

Sponsor: NPS Foundation Research Program

Objective: The main objective is to define practical aerodynamic means for stabilizing discharges of interest for electrical lasers, plasma-chemical devices, etc. Particular objectives are to test the effects of intense, low-frequency turbulence and to compare discharge geometries. This is part of a continuing program.

Summary: Turbulence generated in the shear region of mixing jets, one pulsed, has been examined. For the geometries and flows tested, the scheme was less effective than grid generated turbulence. Also, a new electrode configuration was designed and tested with grid-generated turbulence; results show the superiority of the pin-rack arrangement.

Publication J. L. Barto, "Study of Gas Dynamic Effects on Non-Equilibrium, High-Pressure, Electric Discharges," NPS Technical Report, NPS67-80-005, August 1980.

Conference Presentation J. L. Barto and O. Biblarz, "Gasdynamic Interactions in a Non-Uniform High Pressure Discharge," to be presented at the 33rd Gaseous Electronics Conference, Norman, Oklahoma, 7-10 October, 1980.

Thesis Directed: C. H. Davis, "Aerodynamic Stabilization of an Electric Discharge for Gas Lasers," Master's Thesis of Aeronautical Engineering and Electrical Engineering, September 1980.

**Title:** Study of Basic Mechanisms that Lead to Arcing

**Investigators:** Oscar Biblarz, Associate Professor of Aero-nautics and F. Schwirzke, Associate Professor of Physics and Chemistry.

**Sponsor:** Air Force Weapons Laboratory

**Objective:** The main objective is to study the basic mechanisms that lead to arcing in laser discharges and to develop a discharge model which will aid in the prediction of discharge conditions. This is a new direction for a continuing project.

**Summary:** Arcing or glow collapse severely limits high energy laser performance even in the ionizer/sustainer discharge. This arcing may be caused by a variety of conditions which do not necessarily exist simultaneously and thus it becomes necessary to focus attention on specific devices. We expect to contribute to the understanding of surface contributions to arcing. Work is both analytical and experimental.

**Publications:** O. Biblarz, R. E. Ball, and S. T. van Brocklin, "Electrode Boundary Layers in Dense, Diffuse Plasmas," NPS Technical Report, NPS67-80-0111, March 1980. To appear as an AFAPL-TR.

**Theses  
Directed:** S. T. van Brocklin, "Plasma Boundary Layers in Gas Discharges," Master's Thesis, September 1981.

J. W. Wainionpaa, "Flow Effects on Pulsed Electrical Lasers," Master's Thesis, June 1981.

Title: LDA Investigations

Investigator: Daniel J. Collins, Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objectives: Development of a two-color LDA for Measurement in V/STOL and turbomachinery applications.  
Application of multivariable control concepts to engine and flight technology.

Summary: Extensive measurements have been made in a jet excited by an oscillatory vane in the potential core. This work is reported in the paper listed below. At present all the equipment needed for two color measurements has been assembled. The system with its computer data reduction equipment is now being constructed and tested.  
  
Analysis of parameter insensitive controllers for engine and flight control has begun. Sensitivity analysis programs have been developed and applied to another control problem (see presentations). Investigations are being conducted on sensor trade-offs. A low order model of an engine is under investigation.

Conference  
Presentation: J. A. Matallana and D. J. Collins, "Sensitivity of Analysis of Kalman Filter Used as INS," 46 SAE Aerospace and Guidance Control Meeting, Fort Worth, Texas.

Publication: D. J. Collins, M. F. Platzer, J. C. S. Lai, and J. M. Simmons, "Experimental Investigation of Oscillating Subsonic Jets," Symposium on Numerical and Physical Aspects of Aerodynamic Flows, Long Beach, CA., 19-21, January 1981.

Title: Aero-Optics for an Array of Laminar Flow  
Laser Turrets

Investigator: Allen E. Fuhs, Distinguished Professor of  
Aeronautics, and Physics and Chemistry

Sponsor: Air Force Weapons Laboratory

Objective: To investigate far field diffraction from  
an array of apertures of small size.

Summary: Turbulent and separated flow over laser  
turrets greatly degrades beam quality.  
By reducing scale of the laser turret and  
using multiple apertures, the flow environ-  
ment may be laminar. The far field intensity  
for an array of laminar flow laser turrets  
will be calculated. The questions con-  
cerning the aerodynamic shape of the indivi-  
dual turrets will be addressed. In addition,  
the distribution of laser power to multiple  
turrets will be considered.

Thesis  
Directed: Brian Tousley, "Optics of a Laminar Flow  
Laser Turret," Master's Thesis, September  
1981.

Title: Aero-Optics; Boundary Layer Control for Laser Beam Propagation

Investigators: Allen E. Fuhs, Distinguished Professor of Aeronautics, and Physics and Chemistry, G. N. Vanderplaats, Associate Professor of Mechanical Engineering, Mr. Gregory A. Blaisdell and Ms. Susan E. Fuhs, California Institute of Technology

Sponsor: Air Force Weapons Laboratory

Objective: To determine the degradation of laser propagation due to turbulent boundary layer and turbulent shear layers; propagation wavelength is in the visible or near UV.

Summary: For lasers jointed on aircraft, the beam must traverse a turbulent boundary layer or a turbulent shear layer to exit from the aircraft. For long or medium IR, the effects are not serious. However, in the visible or near UV, the beam quality can be degraded seriously.

Publications: G. N. Vanderplaats, Allen E. Fuhs, and Gregory A. Blaisdell, "Optimized Laser Turrets for Minimum Phase Distortion," Aero-Optics Symposium sponsored by NASA Ames and the Air Force Weapons Laboratory, 14-15 August 1979. Published in the Proceedings of the Aero-Optics Symposium on Electromagnetic Wave Propagation from Aircraft, National Aeronautics and Space Administration Conference Publication 2121, April, 1980, pp. 339-362.

Allen E. Fuhs and Susan E. Fuhs, "Optical Phase Distortion Due to Compressible Flow Over Laser Turrets," Aero-Optics Symposium Sponsored by NASA Ames and the Air Force Weapons Laboratory, 14-15 August 1979. Published in the Proceedings of the Aero-Optics Symposium on Electromagnetic Wave Propagation, from Aircraft National Aeronautics and Space Administration Conference Publication 2121, April, 1980, pp. 287-325.

**Conference  
Presentation:**

The papers were presented by Allen E. Fuhs at the Aero-Optics Symposium on Electromagnetic Wave Propagation from Aircraft, sponsored by NASA Ames and the Air Force Weapons Laboratory at NASA Ames, 14-15 August 1979.

**Title:** Beam Quality in Eximer Lasers

**Investigators:** Allen E. Fuhs, Distinguished Professor of Aeronautics, and Physics and Chemistry, Mr. Gregory A. Blaisdell, California Institute of Technology

**Sponsor:** Office of Naval Research

**Objective:** Investigate Transient index of refraction in an e-beam pumped XeF excimer laser.

**Summary:** Transient refractive index was calculated for an e-beam pumped XeF laser having initial concentrations  $\text{Ne}:\text{Xe}:\text{NF}_3::95.5:4.3:0.2$ . The calculation used Ne in excited states including the transition array  $3s \rightarrow 4p$  and all other constituents in ground state. Lines in  $3s \rightarrow 4p$  array may be resonant with XeF radiation. To obtain the transient populations for Ne, a modification was made to a Naval Research Laboratory computer code which typically accounts for 180-200 reactions involving 50-60 different species. The modified program included populations in 12 electronic configurations of Ne. Electron beam current was changed 10 per cent at constant voltage to simulate the influence of a hibachi shadow. For a nonresonant laser wavelength, an optical pathlength in the laser, L, less than 35 meters will have distortion  $\delta/\lambda$  less than 0.1; however, for a laser wavelength in resonance with Neon, L of only 0.11 meter will cause  $\delta/\lambda = 0.1$ . The difference in optical pathlength is  $\delta$ .

**Publication:** Allen E. Fuhs, James Etchechruy, Lonnie Cole, and Gregory A. Blaisdell, "Transient Refractive Index in a XeF Laser," NPS Technical Report NPS67-80-012, September 1980, pp. 45.

**Conference Presentation:** The paper was presented by Dr. Allen E. Fuhs at the 1980 Annual Meeting of the Optical Society of America at Chicago, Illinois, 14-17 October 1980.

Theses  
Directed:

James Etchechury, "A Simple Model for Calculating the Index of Refraction of Neon I and Neon\*(3<sub>S</sub>) in the Cavity of a Xenon Fluoride Laser," Master's Thesis, June 1979.

Lonnie William Cole, "Computer Program for Kinetics and Populations in a XeF Laser," Master's Thesis, December 1979.

Title: Combat Systems and Ship Arrangements

Investigator: Allen E. Fuhs, Distinguished Professor of Aeronautics, and Physics and Chemistry.

Sponsor: Naval Sea Systems Command

Objective: Determine a quantitative figure of merit for ship arrangements as related to combat system.

Summary: Many factors influence the arrangement of various components of a warship. Arrangements currently are evaluated on the basis of judgement of the ship designer. For computer aided design, a quantitative figure of merit for arrangements is needed which incorporates the interaction of many variables.

Publication: Allen E. Fuhs, "Ship Arrangements and Combat System Performance," NPS Technical Report, NPS67-80-001, January 1980.

Conference Presentation: The workshop on "Ship Arrangements" sponsored by NAVSEA, 21-24 January 1980 was attended. The Technical Report NPS67-80-001 was presented at the Workshop.

Title: Flow Control for an Airborne Laser Turret

Investigator: Allen E. Fuhs, Distinguished Professor of Aeronautics and Physics and Chemistry

Sponsor: Air Force Weapons Laboratory

Objective: To investigate experimentally the efficacy of flow control using suction in the fairing for a laser turret

Summary: A laser turret with 18-inch diameter and fairing was built and mounted in the Naval Postgraduate School smoke tunnel. A large centrifugal blower with 17 inches water and 7500 cfm performance provides suction. The suction does remove regions of flow separation from the turret/faring interface.

Theses  
Directed:

James R. Schonberger, "Flow Control for an Airborne Laser," Master's Thesis, December 1980.

Alan M. Mandigo, "Flow Control for an Airborne Laser," Master's Thesis, December 1980.

Title: Gun Launched Ramjet Guided Missile

Investigator: Allen E. Fuhs, Distinguished Professor of Aeronautics and Physics and Chemistry.

Sponsor: Defense Advanced Research Project Agency

Objective: To screen various Navy missions which are appropriate for a gun launched ramjet guided projectile.

Summary: A ramjet guided projectile is being designed for the antishipmissile defense, ASMD, mission. The projectile will be fired from MK 45 mounts having a 5"54 gun. Other missions are being examined.

Theses  
Directed:

William Parks, "Warhead Design for Ramjet Propelled Guided Projectile for 5"54," Master's Thesis, December 1980.

John S. White, "Aerodynamics and Reaction Jet Control for Ramjet Propelled Guided Projectile For 5"54," Master's Thesis, December 1980.

Robert L. Frazier, "Guidance and Ballistics for Ramjet Guided Projectile for 5"54," Master's Thesis, December 1980.

Gary L. Brown, "Propulsion for Ramjet Propelled Guided Projectile for 5"54," Master's Thesis, December 1980.

James M. Terrell, "Seeker for a Gun Launched Ramjet," Master's Thesis, June 1981.

John F. Moran, "Gun Launched Ramjet," Master's Thesis, June 1981.

**Title:** Probe for Pressure Altitude Fuze for a Broad Jammer

**Investigator:** Allen E. Fuhs, Distinguished Professor of Aeronautics and Physics and Chemistry

**Sponsor:** Naval Weapons Center

**Objective:** To develop a probe which senses ambient pressure from a supersonic projectile or missile.

**Summary:** The jammer is to be activated at 25,000 feet altitude using a probe. The Mach number range is from 1.4 to 2.0 and the angle of attack varies  $\pm$  20 degrees. A probe which senses ambient pressure was built and tested in the Naval Postgraduate School supersonic wind tunnel. Maximum error in measuring ambient pressure was 6 percent over the range of angle of attack at Mach 2. The wind tunnel could not be started at Mach 1.4.

**Thesis  
Directed:** Kenneth Tillotson, "Probe for Pressure Altitude Fuze," Master's Thesis, December 1980.

Title: A Basic Reformulation of the Pipe Flow Stability Problem.

Investigator: T. H. Gawain, Professor of Aeronautics

Sponsor: None

Objective: To reformulate the classical unsolved problem of the hydrodynamic stability of pipe flow in such a way as to obtain an analytical and numerical solution which finally accounts for the experimentally observed facts.

Summary: The present analysis has revealed that the boundary conditions at the axis of the pipe have a complexity which has hitherto been unsuspected. These complex boundary conditions have now been reformulated in a completely general and rigorous fashion thus completing the analytical solution. Extensive numerical calculations still remain to be carried out. The results of these calculations should finally prove or disprove the new theory.

Publications: A technical report is in preparation which summarizes theoretical developments up to this time. Publication of technical papers will be held in abeyance, however, until forthcoming numerical work reveals decisive results.

**Title:** Continuation of Study on ETD Power Generation

**Investigators:** T. H. Gawain, Professor of Aeronautics and  
O. Biblarz, Associate Professor of Aero-  
nautics

**Sponsor:** Department of Energy

**Objective:** To analyze the ETD fluid flywheel design  
with full allowance for compressibility  
and to introduce the concepts of a two-fluid  
ejector into the study. This sponsorship  
of DOE ends with FY80.

**Summary:** The effects of compressibility have been  
calculated and the performance of an all-  
stream system found unsatisfactory. On the  
other hand, a two-fluid system such as mer-  
cury/hydrogen or freon/helium appears to hold  
some promise. Further funding is being sought  
to continue this work.

**Publication:** T. H. Gawain and O. Biblarz, "Analysis of a  
Two-Fluid EHD Power Generator Including  
Effects of Compressibility," NPS Technical  
Report, NPS67-80-002.  
  
Also report NPS67-80-004, in preparation.  
  
T. H. Gawain and O. Biblarz, "Ejector-  
Augmented EHD Power Generation," in  
Advanced Energy Concepts, Hemisphere Press,  
1981.

**Conference  
Presentation:** T. H. Gawain and O. Biblarz, "Estimated  
Performance of an EHD Power Generator  
Which Utilizes a Two-Fluid Ejector,"  
AIAA 13th Fluid and Plasma Conference,  
Snowmass (AIAA-80-1341).

**Patent  
Applications:** O. Biblarz and T. H. Gawain, "Optimally  
Loaded EDH Power Generator," Navy Case  
63,947.  
  
T. H. Gawain and O. Biblarz, "Multistaged  
Electrohydrodynamic Generator with Parallel  
Outputs," Navy Case 64,440.

Title: Unsteady Supersonic Flow Research

Investigator: G. W. H. Hui, Adjunct Professor of Aeronautics (visiting from the University of Waterloo, Ontario, Canada)

Sponsor: Naval Air Systems Command and NASA-Ames Research Center

Objective: To develop a unified analytical method for calculating a supersonic flow past oscillating airfoils and to investigate the limitations underlying the notion of linear unsteady perturbations from known steady flows.

Summary: A generalized Newton-Busemann theory was developed which accounts for centrifugal flow effects. This theory was applied to the analysis of supersonic/hypersonic flow past oscillating airfoils, wings of general planform and bodies of revolution at large angle of attack.

Publications:

G. W. H. Hui (with M. Tobak), "Unsteady Newton-Busemann Flow Theory, Part I: Airfoils," (accepted for publication in the AIAA Journal).

G. W. H. Hui (with M. Tobak), "Unsteady Newton-Busemann Flow Theory, Part II: Bodies of Revolution," (accepted for publication in the AIAA Journal).

G. W. H. Hui (with M. F. Platzer and E. Youroukos), "Stability of Oscillating Supersonic/Hypersonic Wings at Arbitrary Angles of Attack," in progress.

Conference Presentations:

G. W. H. Hui (with M. Tobak), "Unsteady Newton-Busemann Flow Theory, Part I: Airfoils," presented at the 15th International Congress on Theoretical and Applied Mechanics, Toronto, Canada, August 17-23, 1980.

Title: System Safety Software

Investigator: Donald M. Layton, Professor of Aeronautics

Sponsor: NPS Foundation Research Program

Objective: To investigate the analysis techniques that are available and in use for determining the System Safety parameters of software, and to ascertain if the techniques that are in use for analysis of hardware system safety are applicable.

Summary: An examination of several software system safety techniques was made and the generalized techniques were observed. It was determined that these techniques parallel the techniques used for hardware system safety analysis, and, in fact, are generally predicated on the premise that the only safety perturbation in software is one that directs or misdirects a hardware component. The software analysis techniques include a Bottom-to-Top method that is akin to Failure Mode and Effect Analysis, a Top-to-Bottom technique that is related to Fault Tree Analysis, and integrated method that combines some of the features of the other two.

Publication: A Naval Postgraduate School Report is being prepared and a paper is being submitted for the 1981 System Safety Society Conference.

Title: Fatigue in Aircraft Structures

Investigator: G. H. Lindsey, Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To develop improved methods of aircraft fatigue life prediction using data from fatigue monitoring devices currently being flight tested.

Summary: When finally developed and tested, Micro-processor devices used as in-flight fatigue monitors will be supplying nominal elastic stresses and strains in the sequence of their occurrence. To predict fatigue life, these nominal stresses and strains must be used to calculate local ones in the vicinity of notches and holes, which constitute the fatigue critical points. This work has centered on studying the details of typical notch regions including elastic and plastic stress and strain distributions, yield zones residual stresses, etc., all in an attempt to accurately predict fatigue behavior in notched geometries from unnotched material data. This work has been pursued with photoelastic experimental techniques, with finite element numerical methods and with classical analytical methods, all of which are yielding results.

Thesis  
Directed: E. C. Engle, "An Investigation of Residual Stresses in Simulated Wing Panels of 7075-T6 Aluminum," Master's Thesis, December 1979.

Title: Electrohydrodynamic Control of Fuel Injection in Aircraft Engines

Investigator: J. A. Miller and O. Biblarz, Associate Professors of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To investigate the feasibility of using electrohydrodynamic means to control fuel spray characteristics in gas turbine injector systems and thereby optimize combustion efficiency for a wide variety of fuels.

Summary: A T-56 injector nozzle has been modified with a single electrode to permit electrostatic potentials of up to 50KV to be applied to the injection field. Photographic results with a typical fuel indicate that a wide range of droplet size modulation is possible within this voltage range - which is typical of spark plug technology. A laser absorption apparatus has been set up to investigate the possibility of matching droplet size distributions with different fuels. The next phase will include a single can burner set-up in which combustion efficiency can be evaluated directly.

Publications: Informal progress reports have been made to sponsor; a formal report covering the first years results is in preparation.

Theses  
Directed: An Engineer's Thesis by R. Laib is in the later stages of completion. A Master's Thesis by L. Todd is expected to follow.

Patent  
Application: A patent application with R. Laib and O. Biblarz has been filed by ONR.

Title: Holographic Study of Solid Propellant Combustion

Investigator: David W. Netzer, Associate Professor of Aeronautics

Sponsor: Air Force Rocket Propulsion Laboratory

Objective: Holography, high speed motion pictures, light scattering measurements and post-fire particle collection/scanning electron microscopic examination are to be used to study the combustion of composite solid propellants. The immediate goal of the study is to evaluate the relative advantages and disadvantages of the different experimental techniques for obtaining two-phase flow characteristics within the combustion environment of a solid propellant grain.

Summary: All hardware for the laser scattering and holographic measurements has been completed. Initial firings with both motors have been made and calibrations of measurement systems have been completed.

Conference Presentations:

D. W. Netzer, "Size Distribution of Droplets Leaving the Burning Surface of Metallized Solid Propellants," JANNAF Workshop on the Combustion Efficiency of Highly Aluminized Solid Propellants, NASA Langley, Hampton, VA, 25-26 September 1980.

D. W. Netzer, "Size Distribution of Products Leaving the Nozzle of a Solid Propellant Rocket," JANNAF Workshop on the Combustion Efficiency of Highly Aluminized Solid Propellants, NASA Langley, Hampton, VA, 25-26, September 1980.

D. W. Netzer, "Particle Behavior in Solid Propellant Rockets," 1980 AFOSR/AFRPL Rocket Propulsion Research Meeting, Lancaster, CA, 25-27 March 1980.

Thesis Directed:

S. G. Karagounis, "Particulate Behavior in Solid Propellant Rockets," Master's Thesis, June 1981.

Title: Particulate Behavior in Solid Propellant Rocket Motors

Investigator: David W. Netzer, Associate Professor of Aeronautics

Sponsor: NPS Foundation Research Program

Objective: To initiate a detailed and systematic determination of the effects of propellant composition and motor operating environment on the behavior of metallic particulates within solid propellant rocket motors.

Summary: Three experimental techniques were designed and constructed, and initial data were obtained. High speed motion picture studies of six specially formulated propellants were conducted using a windowed combustion bomb. Post-fire residue analysis was also conducted using a scanning electron microscope. Detailed propellant characteristics and filming resolution limits have been obtained for comparison and use with the other experimental techniques; holography of the combustion process in a two-dimensional, windowed motor and light scattering measurements to determine mean particulate size and concentrations.

Conference Presentation: E. Dubrov, V. D. Diloreto, and D. W. Netzer, "Particle Behavior in Solid Propellant Rockets," 17th JANNAF Combustion Meeting, NASA Langley Research Center, Hampton, VA 22-26 September 1980.

Thesis Directed: V. D. Diloreto, "An Experimental Study of Solid Propellant Deflagration Using High Speed Motion Pictures and Post-Fire Residue Analysis," Master's and Aeronautical Engineer's Thesis, June 1980.

Title: Solid Fuel Ramjet Combustion

Investigator: D. W. Netzer, Associate Professor of Aero-nautics

Sponsor: Naval Weapons Center

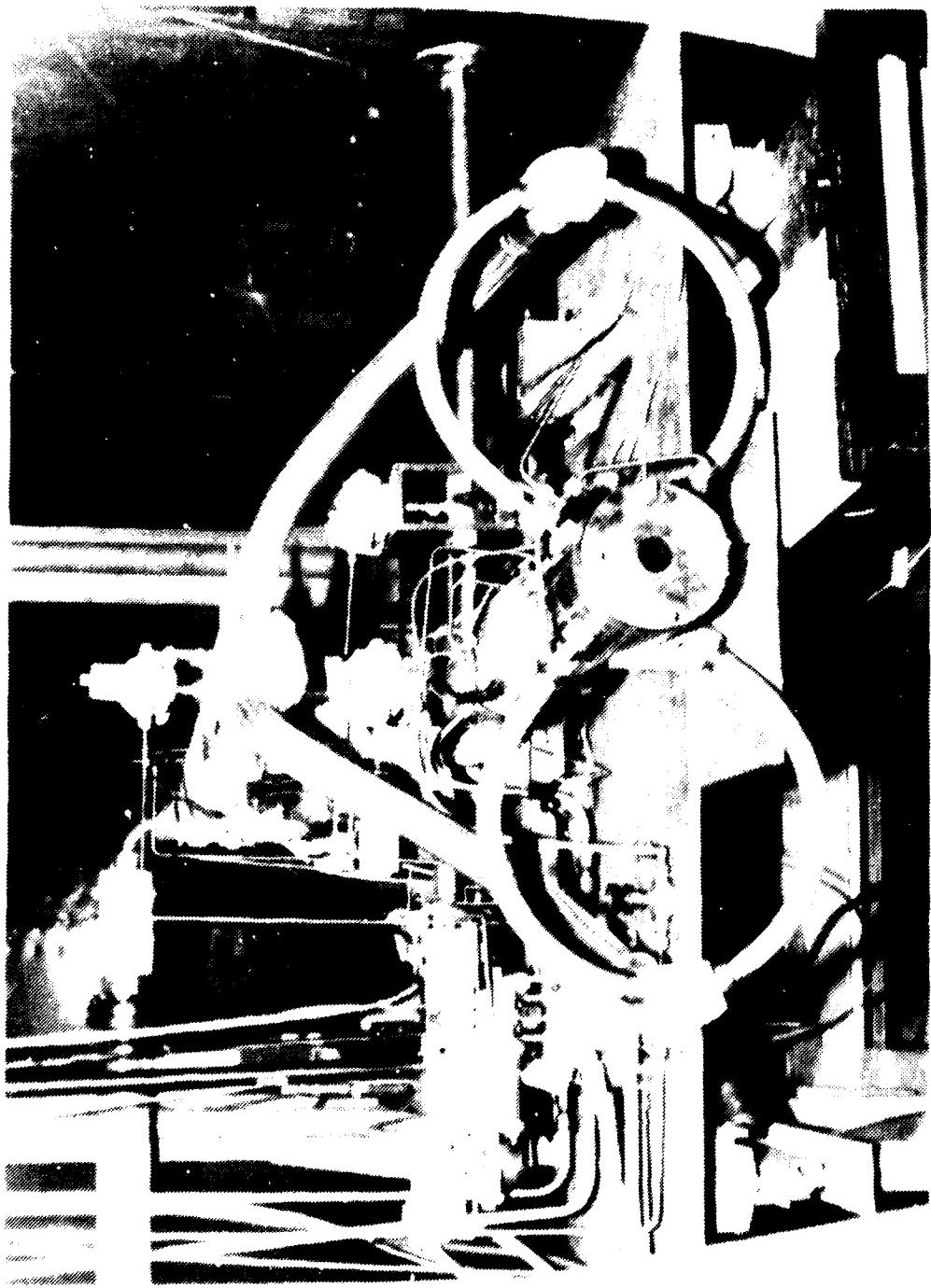
Objectives: To continue development of a computer simulation of the combustion process.  
To determine whether non-reacting flow characteristics and fundamental fuel properties can be used to estimate expected performance from new fuel formulations and combustor geometries.

Summary: Radiative heat transfer has been added to the finite-difference computer code. Initial results appear to agree with experimental data, i.e. increased fuel regression rates are obtained at the aft end of the fuel grain.  
  
Near-wall turbulence intensity in non-reacting flows has been found to correlate with the fuel regression pattern in reacting flow for various combustor geometries. Differential thermal analysis (DTA) and gas chromatography (GC) have been used to evaluate two current and ten proposed solid fuels. Low heating rates (DTA) and high heating rates from a focused laser beam have been used to produce pyrolysis products for GC analysis. Hot firings are being conducted to relate performance to fuel properties/combustor geometry.

Publications: C. A. Stevenson, and D. W. Netzer, "A Primitive Variable Computer Model for Combustion Within Solid Fuel Ramjets," NPS Technical Report, NPS67-79-010, October 1979.  
C. A. Stevenson and D. W. Netzer, "Primitive Variable Model Applications to Solid Fuel Ramjet Combustion," Journal of Spacecraft and Rockets, January, February 1981.

M. E. Hewett and D. W. Netzer, "Light Transmission Measurements in Solid Fuel Ramjet Combustors," accepted for publication in Journal of Spacecraft and Rockets.

- Conference Presentation: D. W. Netzer, "Combustion Behavior of Solid Fuel Ramjets," 17th JANNAF Combustion Meeting 22-26 September 1980, NASA Langley, Hampton, VA.
- Thesis Directed: B. A. Binn, "A Comparison of Solid Fuel Ramjet Flow Characteristics and Combustion Behavior," Master's Thesis, December 1979.
- W. S. Scott, "An Investigation of the Reacting and Non-Reacting Flow Characteristics of Solid Fuel Ramjets," Master's Thesis, September 1980.



TEST STAND FOR THE SOLID FUEL RAMJET COMBUSTION  
PROJECT (PROFESSOR D. W. NETZER).



RAMJET MOTOR FIRING IN THE SOLID FUEL RAMJET  
COMBUSTION PROJECT (PROFESSOR D. W. NETZER).

Title: Turbojet Test Cell Aerodynamics and Emission Levels

Investigator: David W. Netzer, Associate Professor of Aeronautics

Sponsor: Naval Air Propulsion Center

Objectives: Develop and experimentally validate a computer model which can be used to assess the effects of engine operating conditions and turbojet test cell design on the flow field and engine exhaust distribution within the test cell augmentor tube.

Experimentally determine the effects of fuel additives and test cell design on emitted particulate levels.

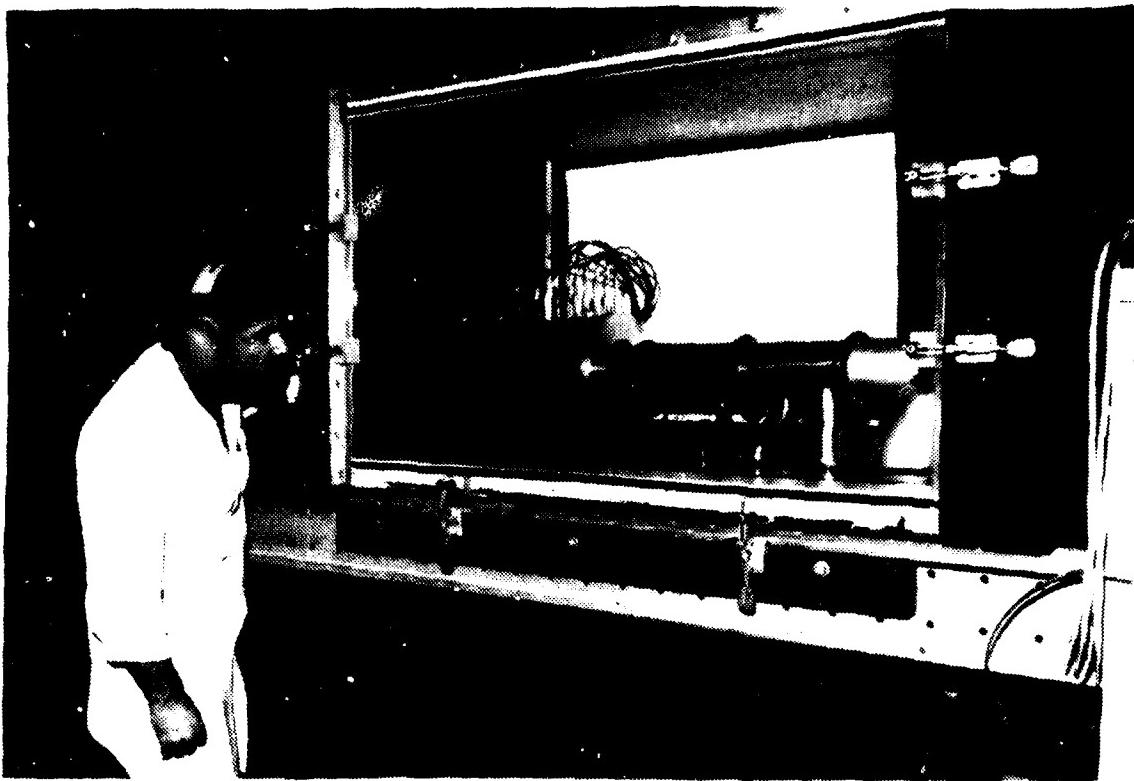
Summary: Computer model validation efforts were completed. Data obtained from tests at NAS, Alameda were compared to model predictions. Model predictions of velocity and pressure distributions were found to agree reasonably well with experimental data for various engine operating conditions. Least accuracy was found to occur at high augmentor tube where three-dimensional effects became significant.

Initial tests were completed using the sub-scale test cell to examine the effects of fuel additives on emitted particulates. Ferrocene was found to be quite effective in reducing plume opacity. DGT-2 and XRG were found to be ineffective. Particulate size and concentration measurements are currently being measured at the engine and test cell stack exhausts.

Publication: C. A. Stevenson, and D. W. Netzer, "A Primitive Variable Mathematical Model for Predicting the Flows in Turbojet Test Cells," NPS Technical Report, NPS67-79-009, October 1979.

Theses  
Directed: R. R. Darnell, "Effects of Fuel Additives on Plume Opacity of Sub-Scale Turbojet Test Cell with a Ramjet Type Dump Combustor," Master's Thesis, December 1979.

P. J. Mallon, "Validation of a Two-Dimensional Primitive Variable Computer Code for Flow Fields in Jet Engine Test Cells,"  
Master's Thesis, June 1980.



PATRICK HICKEY, AEROSPACE ENGINEERING  
TECHNICIAN, EXAMINING SUBSCALE TURBOJET  
TEST CELL FOR THE STUDY OF EFFECTS OF  
FUEL ADDITIVES ON EMITTED POLLUTANTS.

Title: Validation of Air Quality Assessment Model  
for Naval Air Operations

Investigator: David W. Netzer, Associate Professor of  
Aeronautics

Sponsor: Naval Air Propulsion Center

Objective: To complete the development of AQAM for  
Naval Air Operations and Validate the Model  
with data obtained at NAS, Miramar, CA.

Summary: A joint effort by NAPC, NPS, NAS Pt. Mugu  
and EPA was conducted at NAS Miramar. De-  
tailed operational data were collected to-  
gether with meteorological and pollution con-  
centration data. Pollutant distributions  
were then compared to AQAM predictions.  
Results from earlier wind tunnel measure-  
ments of jet dispersion rates were also in-  
corporated in AQAM. Predicted CO concentra-  
tion were in good agreement with experiment.  
Predicted NOX concentrations from aircraft  
idle/taxi operations were too low. Predicted  
total hydrocarbons and particulate concen-  
trations were too high for aircraft idle/  
taxi operations and too low for environ-  
sources. Model modifications are being  
investigated to improve prediction accuracy.

Publication: J. V. Brendmoen and D. W. Netzer, "Atmos-  
pheric Dispersion of High Velocity Jets,"  
NPS Technical Report, NPS67-79-012, November  
1979.

Thesis  
Directed: T. S. Douglas, "Validation of an Ambient  
Air Quality Model for Naval Air Operations,"  
Master's Thesis, December 1979.

Title: Investigation of V/STOL Propulsion Problems

Investigator: M. F. Platzer, Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To investigate flow phenomena in V/STOL aircraft propulsion systems and to perform V/STOL aircraft concept feasibility studies.

Summary: A new jet excitation mechanism has been identified which shows the potential of significantly increasing the secondary flow entrainment in thrust augmenting ejectors without impairing the nozzle efficiency. Mean velocity measurements using pitot tubes and laser-doppler anemometry demonstrated significant entrainment increases for three pressure ratios. A patent application is currently being processed by the Navy Patent Office in San Francisco. Also, the analysis of unsteady supersonic cascade flows has been continued and a technology assessment of Navy-V/STOL fighter aircraft has been completed.

Publication: W. H. Hui, M. F. Platzer, and E. Youroukos, "Stability of Oscillating Supersonic/Hypersonic Wings at Arbitrary Angles of Attack," to be submitted to AIAA Journal.

Conference Presentation: D. J. Collins, M. F. Platzer, J. C. S. Lai, and J. M. Simmons, "Experimental Investigation of Oscillating Subsonic Jets," Symposium on Numerical and Physical Aspects of Aerodynamic Flows, Long Beach, CA, January 1981.

Thesis Directed: R. A. Burnett, "Navy V/STOL Fighter-A Technology Assessment," Master's Thesis, June 1980.

Title: Aircraft Flight Parameter Identification

Investigator: Louis V. Schmidt, Professor of Aeronautics

Sponsor: Naval Air Development Center

Objectives: To obtain a baseline set of flight time history data for a contemporary Navy Fighter Aircraft (F-14).  
To analyze reference flight data by the Modified Maximum Likelihood Estimation (MMLE) Parameter Identification Technique.  
To document, report and provide instruction on usage of the MMLE technique to the sponsoring organization.

Summary: In addition to NASA related activities, became familiar with the NASA aircraft parameter identification code, MMLE-3, and transferred the computer code plus base-line F-14 flight data with sample test cases to NADC. Transferred the software and test cases from the F-14 flight simulator program to NADC in order to expedite NADC's own inhouse efforts on stall/spin simulation. Finally, presented a four hour seminar series on static aeroelastic effects upon airframe/stability and control both at the NASA Dryden Flight Research Center and at the Naval Air Development Center with particular focus being on the influence of sweep forward of the wings.

Title: Applied Research in Engineering Technology

Investigator: L. V. Schmidt, Professor of Aeronautics

Sponsor: Office of the Assistant Secretary of the Navy

Objective: Provide technical support to the assistant for Engineering Technology.

Summary: Assumed the position of Acting Assistant for Engineering Technology in the OASN (RE&S). Duties included administering research contract reviews, visiting laboratory facilities and assisting in policy establishment for Navy 6.1, 6.2 and 6.3A research upon aircraft, missile, ship, submarine and boat platforms in the disciplines of fluid mechanics, propulsion and structures.

Title: Flight Mechanics Research

Investigator: L. V. Schmidt, Professor of Aeronautics

Sponsor: NASA Dryden Flight Center

Objective: Provide on-site instruction of a graduate level flight mechanics course comparable to AE 4301 and also provide consulting support to ongoing flight research programs.

Summary: Conducted on-site graduate course (NPS accredited) in flight mechanics to NASA engineers. In addition, participated in a joint NAVY/NASA high angle of attack flight research program using the F-14 aircraft. Modified the digital computer code on the flight simulator to accommodate flight attitudes above sixty degrees for stall/spin research. Also conducted studies on F-14 wing rock behavior using both flight data and analytic modeling.

Title: Axial Compressor Flow Fields

Investigator: Raymond P. Shreeve, Associate Professor of Aeronautics

Sponsor: Office of Naval Research

Objective: To improve our understanding of flow fields in axial compressors and to obtain detailed measurements against which new computer codes can be verified.

Summary: The complete definition of the flow field leaving a high speed single stage axial rotor in a rotor-first arrangement is being attempted using a new measurement technique. Two semi-conductor probes of simple geometry are used together with "synchronized sampling" to measure the periodic component of the velocity (vector) field. Comparison with two component LDV measurements of the same flow field is planned. To date, the distribution of flow yaw angle on the annulus centerline has been measured in the compressor using a single probe, and the first data were obtained from the compressor with a system of two probes. Multiple techniques for deriving the velocity vector from the two probe system have been devised and the required software has been written. Tests to obtain rotor exit velocity map data at high rotational speeds will resume shortly.

Publications:

R. P. Shreeve, A. G. McGuire, and J. A. Hammer, "Calibration of a Two Probe Synchronized Sampling Technique for Measuring Flows Behind Rotors," paper presented at IEEE International Congress on Instrumentation in Aero-Space Simulation Facilities, Monterey, CA. September 24-26, 1979. Proceedings, ICIASF'79 Record, IEEE Catalogue No. 79CH1500-8AEs.

D. Adler, and R. P. Shreeve, "A General Procedure for Obtaining Velocity Vector from a System of High Response Impact Pressure Probes," Naval Postgraduate School Technical Report, NPS67-79-007, July 1979.

D. Adler, and P. M. Taylor, "A Procedure for Obtaining Velocity Vector from Two High Response Impact Pressure Probes," Naval Postgraduate School Technical Report, NPS67-80-007, August 1980.

Title: Cascade Studies of Flows Through Compressor Bladings

Investigator: Raymond P. Shreeve, Associate Professor of Aeronautics

Sponsor: National Aeronautics Space Administration

Objective: To obtain data using the Cascade Wind Tunnel at the Turbopropulsion Laboratory at NPS to verify computational codes to compute 2-dimensional flow through compressor cascades.

Summary: Preliminary work was done to obtain uniform inlet conditions and periodic flow conditions through the test cascade. Following rework of the plenum geometry, two test cascades were run having different numbers of blades, aspect ratios and diffusion factors. It was concluded that satisfactory test conditions could be achieved without wall suction at an aspect ratio of two if an axial velocity-density ratio of 1.06 was accepted. Test blades were designed to given contours based on these findings.

Publications: A. G. McGuire, "Subsonic Cascade Wind Tunnel-Prepatory Test Results," NPS Turbopropulsion Laboratory Tech. Note, TPL TN-80-05, August 1980.  
D. Duval, "Data Acquisition Programs for the Subsonic Cascade Wind Tunnel," NPS Turbopropulsion Laboratory, Tech. Note, TPL TN-80-03, August 1980.

Theses Directed: R. C. Moebius, "Analysis and Testing to Improve the Flow From the Plenum of a Subsonic Cascade Wind Tunnel," Master's Thesis, March 1980.  
D. Duval, "Evaluation of a Subsonic Cascade Wind Tunnel for Compressor Blade Testing," Master's Thesis, September 1980.

Title: Development of a Transonic Compressor Model

Investigator: Raymond P. Shreeve, Associate Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To develop a small transonic axial air compressor model and establish methods of measuring the performance and flow behavior in small machines.

Summary: Performance tests were carried out to 21,200 RPM. Extensive instrumentation was developed for tests to design speeds. Data acquisition equipment was upgraded to employ fast acquisition of all data by mini-computer. Software was completed and final test series were begun. Bearing failure at only 15,300 RPM required rework of drive turbine rotor and caused 6 months delay. Reassembly of the rig is nearly completed; testing to high speeds will be completed in coming months. Modifications of the test rig for flutter were studied in the interim.

Publications:

H. Zebner, "Transonic Compressor: Program System TXCO for Data Acquisition and On-Line Reduction," NPS Technical Report, NPS67-80-009, September 1980.

T. Eargle, "Performance Evaluation of an Air Research T-18A40 Turbocharger with Applications to the Transonic Compressor Test Rig," NPS TPL TN79-04, September 1979 (Internal Technical Note).

M. J. Kaiser, "T18A40 Turbocharger Performance," NPS TPL TN80-02, July 1980 (Internal Technical Note).

**Title:** Multi-Stage Compressor Study

**Investigator:** R. P. Shreeve, Associate Professor of Aero-nautics

**Sponsor:** NPS Foundation Research Program

**Objective:** To reblade and instrument a large 3 stage axial compressor and carry out baseline measurements of the performance of newly designed "symmetrical" blading.

**Summary:** The compressor is 36 inches O.D. and has cylindrical flow path 7.2 inches high. All blades are individual and adjustable. In the present program, 240 cast-epoxy blades of new design were hand-finished, jiggled, trimmed and one stage was assembled in the machine to a minimum tip clearance (0.020"). Traversing velocity, and fixed Kiel probes, and a new computer data acquisition system with Scanivalves were installed. Preliminary measurements of the stage performance were obtained at 1200 RPM. The work was documented in Tech Notes. from which a report will be issued. Following completion of the early measurements, an investigation of tip clearance and other 3-dim. flow effects is planned.

**Publications:**

- I. Moyle, and H. Zebner, "Multi-Stage Compressor Installation of Cast-Epoxy Blades," NPS Turbopropulsion Laboratory Tech. Note TPL TN 80-06, October 1980.
- I. Moyle, "Multi-Stage Compressor-Data Acquisition Software," NPS Turbopropulsion Laboratory Tech. Note TPL TN 80-07, October 1980.
- I. Moyle, "Multi-Stage Compressor-Circumferential Rake Design and Fabrication," NPS TPL TN 80-08, October 1980.
- I. Moyle, "Multi-Stage Compressor-Initial Measurements with One Stage of Symmetrical Blading," NPS Turbopropulsion Laboratory, Tech. Note TPL TN 80-09, October 1980.

Title: Transonic Compressor Investigation

Investigators: Raymond P. Shreeve, Associate Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To determine by measurement the behavior of the flow through transonic axial compressor bladings in order to appraise and improve predictive analytical models for steady and unsteady effects.

Summary: In earlier phases of the program, a single stage axial compressor and test rig were designed, built, installed and tested to transonic flow conditions. New measurement techniques were developed and applied to define the internal flow field. Emphasis was put on computer techniques for acquiring and processing both steady state and high speed data and this phase was recently completed. Acquisition of flow field information at high speeds was underway when bearing failure caused a 6 month test delay. Testing is to resume shortly. Successful tests were made of a small transonic cascade model of the rotor tip flow and a major success was the introduction of a straight forward general method for representing the calibration of flow probes.

Publications:

D. Adler, and P. M. Taylor, "A Procedure for Obtaining Velocity Vector from Two High Response Impact Pressure Probes," NPS Technical Report, NPS67-80-007, August 1980.

H. Zebner, "Procedure and Computer Program for the Representation of Calibration Surfaces (with Application to Multiple Sensor Flow Probes)," NPS Technical Report, NPS67-80-008, August 1980.

A. G. McGuire, "Pneumatic Velocity Probe Calibration - Users Manual for Data Acquisition and Reduction," NPS TPL TN 80-01, February 1980 (internal Technical Note).

Thesis  
Directed: C. Volland, "Transonic Cascade Wind Tunnel  
Modification and Initial Test," Master's  
Thesis, March 1980.

## DEPARTMENT OF OCEANOGRAPHY

The research program of the Department of Oceanography may be considered under five headings according to the facilities utilized and topics considered. These headings are: ship programs; coastal ocean studies; shore processes studies; open ocean studies; and special studies.

### SHIP PROGRAMS

The investigators in this category make use of the Naval Postgraduate School research vessel ACANIA, a ship supported by the Commander, Naval Oceanography Command; also, some investigators make use of other ships.

C. N. K. Mooers took the lead in procurement of (1) an onboard satellite IR and visible image receiving and processing system and (2) an acoustic doppler speed profiler. The sponsor is the NPS Foundation Research Program.

### COASTAL OCEAN STUDIES

C. N. K. Mooers uses the ACANIA to study the physical dynamics of the Pt. Sur coastal upwelling center. The sponsor is the NPS Foundation Research Program.

J. B. Wickham and S. P. Tucker have completed the field phase of an observational study of the California Countercurrent. It has two parts: a year's continuous monitoring of the core of the Countercurrent with an array of moored current meters and sensors of water mass properties; and a broader monthly sensing of the region of the Countercurrent with densely spaced continuous profiling of the water mass properties. The study region is one of relatively uncluttered sea floor topography on the continental slope and borderland south of Point Sur. The sponsor was NASA. New funding is to be sought for the analysis phase.

E. C. Haderlie uses ACANIA to carry out a study of the biology of stone and wood boring organisms in the deeper waters of the Monterey Bay. His purpose is to determine the identity and the vertical and horizontal distribution of these borers as well as their growth rates, settlement times, and destructive effects. The sponsor is the Office of Naval Research.

E. D. Traganza uses ACANIA off the coast of California in a study of chemical mesoscale associated with ocean fronts in the coastal upwelling region off Point Sur. Cruises are coordinated with satellite imagery obtained from the National Environmental Satellite Service at Redwood City. This study attempts to link physical, chemical, biological, and acoustic properties in this and similar regions. The sponsor is the Office of Naval Research.

#### SHORE PROCESSES STUDIES

E. B. Thornton is studying the kinematics and energetics of breaking waves in the surf zone. His research is based on measurements of water particle motion within the surf zone. Measurements are being made at La Jolla and Santa Barbara as part of the National Nearshore Sediment Transport Study. NOAA/Sea Grant and the Office of Naval Research are the sponsors.

E. C. Haderlie uses concrete wharf pilings and other structures on the coast in investigating organisms responsible for deterioration of engineering materials placed in the sea and in determining the general biology and destructive effects of these organisms. NCEL was the sponsor.

#### OPEN OCEAN STUDIES

R. G. Paquette and R. H. Bourke make use of U. S. Coast Guard ice breakers to observe and analyze ocean thermal fine-structure near the ice margin in the Chukchi Sea. These studies have acoustical applications. The sponsor is the Arctic Submarine Laboratory, NOSC.

Physical factors affecting sound propagation in the ocean are being studied by E. B. Thornton. Spatial and temporal variability of upper ocean physical and acoustical variables have been measured from arrays deployed from ACANIA. The sponsor is the NPS Foundation Research Program.

R. W. Garwood in conjunction with R. L. Elsberry and R. L. Haney of the Department of Meteorology is modeling upper ocean thermal structure. Their investigations of the ocean surface turbulent boundary layer to atmospheric forcing have led to the development of models that can be used to compute upper ocean thermal structure changes if the atmospheric conditions are known. The Office of Naval Research is the sponsor. The success of these models under test conditions has led to an applied research program in which the models shall be used to aid in the analysis of the upper ocean thermal structure, especially in those regions of the ocean that lack frequent observations. NORDA, is the sponsor. A spin-off of this research is an effort to couple an oceanic general circulation model to an oceanic boundary layer model.

Ocean observations taken along latitude sections in the Atlantic Ocean during IGY have been used by G. H. Jung as the basis for new geostropic calculations of mass, salt and heat transported in that ocean. Values of heat carried by these large scale circulations in the North Atlantic are being compared to values transported by various smaller scale phenomena there; South Atlantic Ocean computations are also completed as well as data for two South Pacific Ocean sections. On North Pacific section is being readied for computation. All ocean transports are being compared to associated climatic anomalies of the data period.

C. N. K. Mooers participates in FRONTS, a multi-institutional experiment to analyze the subtropical front of the North Pacific. His role is to analyze the atmospheric forcing, make use of the FNOC and NEPRF oceanographic surface and subsurface fields, and develop a diagnostic model for oceanic fronts. The sponsor is the Office of Naval Research.

#### SPECIAL STUDIES

A. Milne, who occupied the ONR Chair in Arctic Marine Science, studied the Cape Bathurst Polynya and the heat budget and currents of the southeast Beaufort Sea. The Office of Naval Research is the sponsor.

J. J. von Schwind has published volume one of an introductory textbook in geophysical fluid dynamics for oceanographers, published in 1980 by Prentice Hall. Naval Ship Systems Center (NSSC) was the sponsor.

G. H. Jung, R. H. Bourke, and LCDR C. Dunlap study relations between atmospheric and oceanic variations and long range, low frequency sound propagation in the North Pacific Ocean. The sponsor is NOSC (for COSP and NAVLEX).

S. P. Tucker is assessing Soviet work in optical oceanography. The sponsor is the Naval Intelligence Support Center (NISC).

**Title:** Studies of the Oceanic Planetary Boundary Layer

**Investigator:** Roland W. Garwood, Jr., Assistant Professor of Oceanography

**Sponsor:** Office of Naval Research

**Objective:** To understand by means of model simulations and data analysis the role of the oceanic planetary boundary layer in the distribution of energy, momentum and mass in the upper ocean.

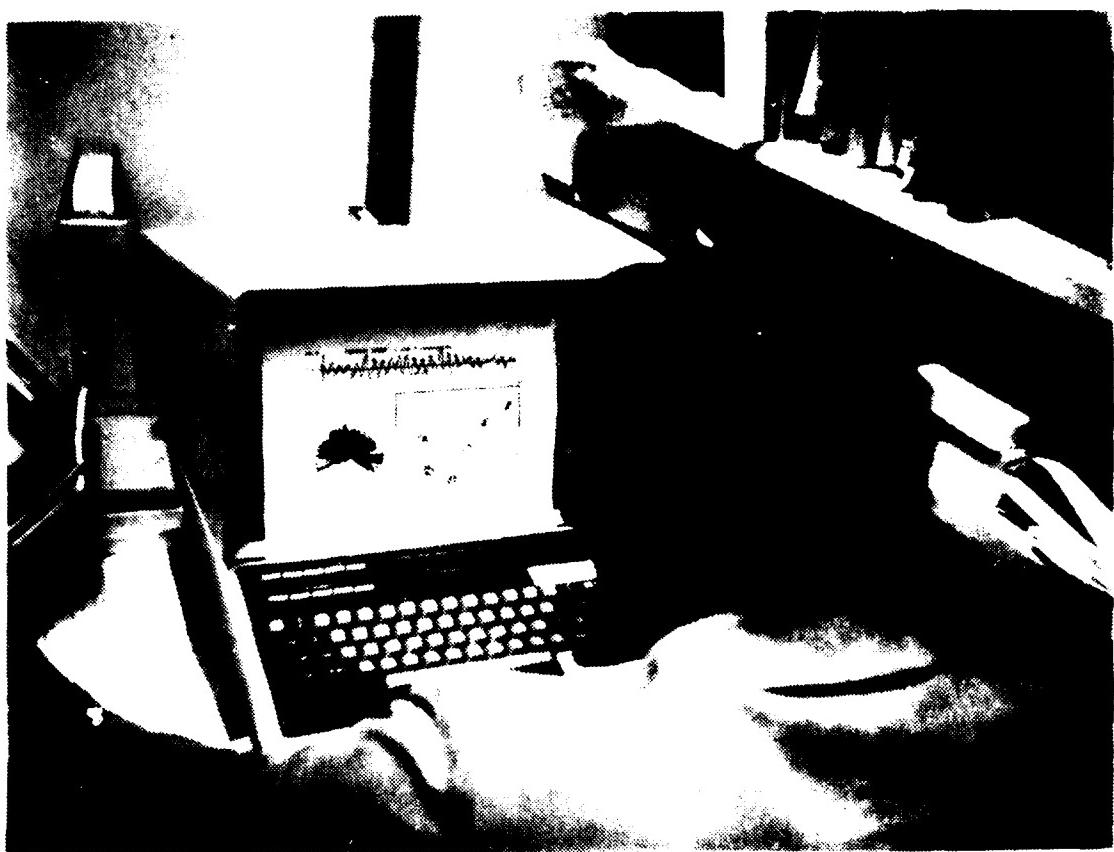
**Summary:** This project is in part a continuation of studies begun in an ONR-sponsored project with R. L. Elsberry from 1976 to 1980. There are two primary new elements to be undertaken this year: (i) a model study of the response of a two-dimensional upper ocean density front to local non-stationary atmospheric forcing, and (ii) a critical examination of turbulence dynamics and process parameterization in mixed layer model closure. The first of these elements is now possible only because of the successful embedding of the Garwood (1977) turbulence closure mixed layer model into the Haney (1975) ocean circulation model. This task was completed by Adamec, Elsberry, Garwood and Haney under the sponsorship of the Naval Postgraduate School Foundation and the Office of Naval Research from 1977 to 1980.

**Publications:** R. W. Garwood, Jr., "Air-Sea Interaction and Dynamics of the Surface Mixed Layer," a U.S. Report to the International Union of Geodesy and Geophysics, in Reviews of Geophysics and Space Physics, 17 (7), 1507-1524.  
R. L. Elsberry and R. W. Garwood, Jr., "Numerical Ocean Prediction Models--Goal for the 1980's," accepted for publication in the Bulletin of the American Meteorological Society.

Conference

Presentations: R. W. Garwood, Jr., D. Adamec and R. L. Elsberry, "Numerical Simulation of the Effect of Surface Heating and Stratification upon an Ocean Surface Density Front," presented at Third Air-Sea Interactions Conference of the American Meteorological Society, January 1980, Los Angeles.

D. Adamec, R. L. Elsberry, R. W. Garwood and R. L. Haney, "Coupling a Mixed Layer Model with a General Circulation Model," presented at the Fall Annual Meeting of the American Geophysical Union, December 1979, San Francisco.



PROFESSOR R. W. GARWOOD RUNNING  
A NUMERICAL OCEAN MODEL.

Title: Biology of Stone and Wood Boring Animals in the Monterey Submarine Canyon and the Deeper Waters Off the Central California Coast

Investigator: E. C. Haderlie, Distinguished Professor of Oceanography

Sponsor: Office of Naval Research

Objective: To determine the distribution of stone and wood borers in the deeper waters of Monterey Bay and offshore of wood and various kinds of stone in the sea.

Summary: During the Fall of 1979 and the first half of 1980 new arrays in deeper water have been deployed and recovered for analysis of borer activities. Samples of stone known to carry infestations of borers have been brought to the laboratory on a regular basis and x-rayed to determine rates of growth.

Publications:

E. C. Haderlie, 1980a, "Seastar Predation on Rock Boring Bivalves," The Veliger 22 (4): 392.

E. C. Haderlie, 1980b, "Stone Boring Marine Bivalves from Monterey Bay, California," The Veliger, 22 (4): 345-354.

E. C. Haderlie, 1980c, "Stone Boring Marine Bivalves as Related to the Geology of Monterey Bay, California," pp. 231-248; Proceedings of the 5th International Congress on Marine Corrosion and Fouling, Editorial Garci, Madrid, Spain.

**Title:** Oceanographic Studies in Support of COMOCEAN-SYPAC (COSP)

**Investigator:** G. H. Jung, Professor of Oceanography, R. H. Bourke, Associate Professor of Oceanography, and LCDR C. R. Dunlap, Assistant Professor of Oceanography

**Sponsor:** Naval Ocean Systems Center

**Objective:** Development of relations between environmental variables and low frequency acoustic transmission in the North Pacific Ocean.

**Summary:** COSP has identified problems for study at NPS which include (1) analysis of long range acoustical experiments made in conjunction with the Mixed Layer Experiment (MILE) in the Northeast Pacific in 1977, wherein particular effects of storm mixing in the upper ocean were traced in the received acoustic signal; (2) comparison of the NOAA Global Operational Sea Surface Temperature Computation (GOSSTCOMP) from satellite measurements with ground truth and Fleet Numerical Oceanographic Center chart values, to show GOSSTCOMP has a definite warm bias of some 3.9°C compared to the other values, and that it may provide useful information in the absence of (or in conjunction with) other measurements; and (3) evaluation of effects of ocean frontal systems and eddies on low frequency sound propagation, wherein unusual detection patterns may be explained.

**Publication:** Unpublished progress reports were made to the Sponsor on 3/31, 7/9 and 9/24/80.

**Conference Presentations:** Fred C. Klein, and G. H. Jung, "Comparison of Three Methods of Determining Values of Sea Surface Temperature," at 1979 Fall Meeting of the American Geophysical Union, San Francisco, CA., December 7, 1979. Abstract published in EOS 60 (46) pp. 859-60. (see item IIc1).

Thesis  
Directed: Mark K. Frye, "An Evaluation of the Impact  
of Environmental Information on Predicting  
the Performance of Long Range ASW Surveil-  
lance in the North Pacific," Master's  
Thesis and NPS Technical Report, NPS71-80-  
002, March 1980.

**Title:** Point Sur Cold Wedge

**Investigator:** Christopher N. K. Mooers, Professor, Chairman,  
Department of Oceanography

**Sponsor:** NPS Foundation Research Program

**Objective:** Develop a predictive capability for the occurrence, three-dimensional structure, and evolution of coastal upwelling centers; e.g., the so-called "cold wedge" off Point Sur, CA. This predictive capability will use a combination of geophysical fluid dynamics principles, oceanic climatology for local upwelling events, bathymetry, surface wind analyses, and satellite remote sensing of sea surface temperature and perhaps other variables to infer the initiation, structure, and evolution of coastal upwelling centers.

**Summary:** The "cold wedge" off Point Sur is a thermal anomaly which is frequently noted in satellite IR data. It is known to be associated with oceanic fronts and eddies, coastal upwelling, submarine canyon topography, and the California Undercurrent, yet its dynamical nature has not been determined, nor has its generation, propagation or advection, and dissipation been modeled for purposes of ocean prediction. Such features are common off the west coast of continents. They have temperature anomalies of several degrees Celsius, and they are ca. 50 km wide and 300 m deep. Hence, they produce substantial anomalies in acoustic propagation, and a predictive knowledge of their development would contribute to the conduct of naval warfare.

The magnitude and nature of the processes associated with coastal upwelling centers are such that a several-year research program of field observation, analysis, and model development is required. The present research project is a pilot, repeated synoptic field study and analysis designed to provide the scientific basis for proposing a substantial observational, analysis, and modeling program to another potential sponsor; e.g., NASA, NSF, NORDA, or ONR.

A three-week pilot synoptic study was conducted in June 1980, principally from the R/V ACANIA. During the first and third weeks, a pair of XBT grids were occupied each week over a 90 km by 120 km coastal ocean domain centered on Sur Canyon. The 210 XBT casts were supplemented with 106 STD casts, continuous surface thermosalinograph traces, and other routine oceanographic and meteorological measurements. (During the second week, Dr. Traganza conducted an area study of the surface distribution of nutrients and organic substances off Point Sur). During the third week, R/V ACANIA's observations were supplemented by AXBT and ART data acquired from a C130 of the USCG and surface current data obtained from a SRI shorebased HF backscatter.

The pilot study was conducted during a period of sustained upwelling; in fact, there was an intense upwelling wind event during each of the three weeks. Nearshore sea surface temperatures in the upwelling center were 3 to 5 C cooler than 25 km offshore; occasionally, they dropped by as much as 1C/1km across oceanic fronts. The surface area of the upwelling center increased with upwelling favorable winds. The upwelling center was manifested in thermal structure to a depth of at least 100 m and was clearly associated with bottom topography.

Publication: An abstract has been submitted for a talk at the American Geophysical Union's Winter Annual Meeting in San Francisco, 6 to 10 December 1980. A manuscript is intended for submission to the Journal of Geophysical Research.

Thesis  
Directed: This winter a Ph.D dissertation proposal is being prepared by Mr. L. F. Breaker, NOAA/NESS to integrate this data set with satellite IR images, winds and coastal sea level time series, etc. An expanded and long-term proposal is planned for submission to NASA, NSF, NORDA, or ONR in the coming months.

Title:                   Synoptic Studies of Oceanic Fronts

Investigator:           Christopher N. K. Mooers, Professor and Chairman of Oceanography

Sponsor:               Office of Naval Research

Objective:             This was the first year of a two-year study of oceanic fronts being conducted as part of the ONR-sponsored, multi-institutional informal program called FRONTS, which involves a field study, and subsequent analysis, of the North Pacific Subtropical Front. The field study was mainly conducted between early December 1979 and late February 1980. It involved two research vessels, Navy P3 aircraft, satellite-tracked drifters, and about twenty individual projects. The NPS project had as its motivating objective the development of a diagnostic model to improve our ability to analyze oceanic fronts. The project has several preliminary components directed to achieve the above objective, and to support the overall field study:

1. The analysis of synoptic scale atmospheric forcing information available from FNOC in the FRONTS domain, which is ca.  $10^\circ \times 10^\circ \times 100$  days.
2. The analysis of ocean thermal fields available from FNOC.
3. The analysis of GOES WEST IR imagery using the SPADS image processing facility at NEPRF.

A subsidiary objective is to evaluate the FNOC and NEPRF products vis-a-vis the "Sea Truth" available from the FRONTS field study. This evaluation is a necessary precursor to producing an enhanced analysis.

Summary:               At the end of the first year, the data base referred to in 1 and 2, above had been acquired from FNCO by subcontractors and set-up and screened at NPS. They were examined and partially reported to interested investigator to one of whom a complete copy was

sent on computer tape. Due to difficulties associated with equipment upgrades, SPADS was unable to capture GOES WEST data during FRONTS as referred to in 3 above. However, a copy of the data was purchased from the University of Wisconsin for processing on SPADS by subcontractors. Due to extensive cloud cover, not much of the sea surface was detectable during FRONTS. There is some hope that at least one usable image will be produced.

As noted below, an abstract was submitted for presentation of very preliminary results at the December 1980 meeting of the American Geophysical Union.

In the next year, it is planned to further analyze the atmosphere forcing and ocean thermal structure fields, to participate in the program-wide integration of results, and to develop and evaluate the diagnostic model. A search to fill a postdoctoral level position to work on this project is still in progress. Planning of future studies is also intended.

Publication: C. N. K. Mooers, "Atmospheric Forcing and GOES IR Imagery During FRONTS," EOS, 61, (46): 1001 (abstract only), 1980.

Title: Studies of Oceanographic Conditions Near the Marginal Sea-Ice Zone, MIZPAC 80

Investigators: Robert G. Paquette, Professor of Oceanography and Robert H. Bourke, Associate Professor of Oceanography.

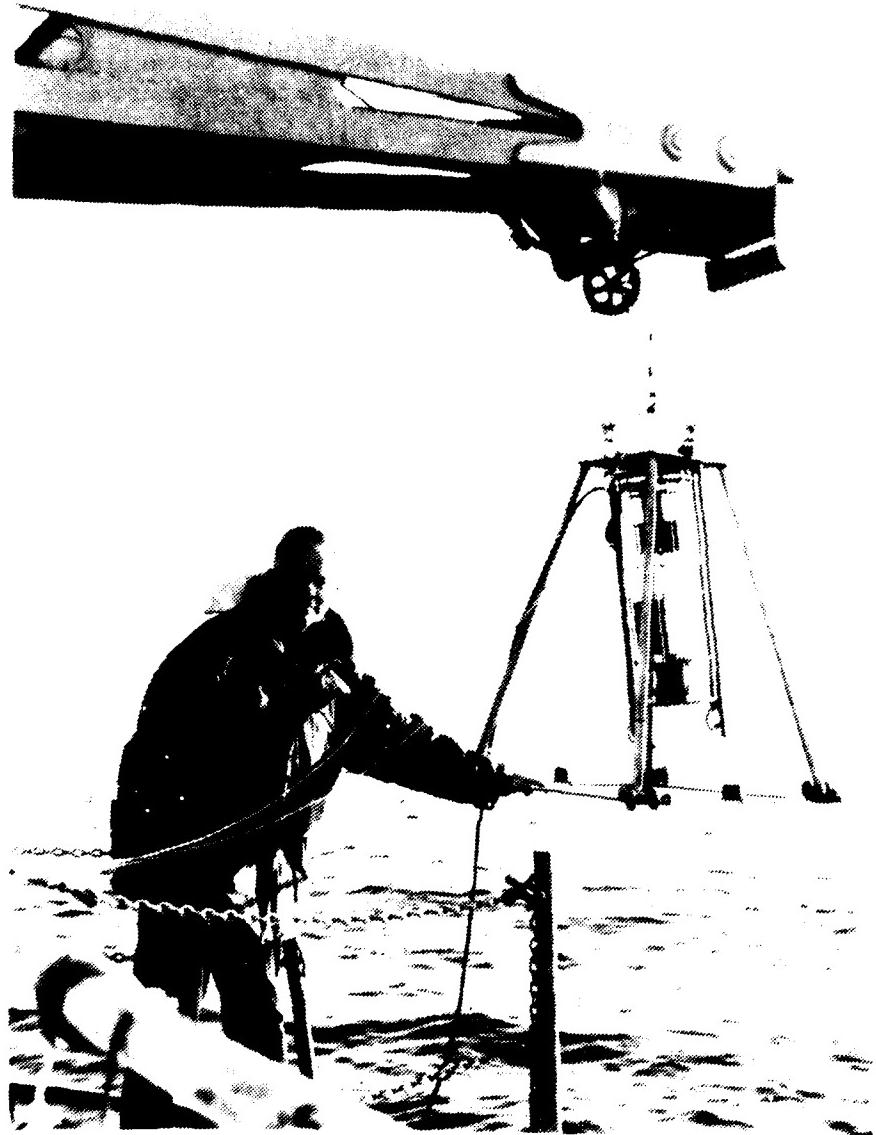
Sponsor: Naval Ocean Systems Center

Objective: Continue with analysis of oceanographic conditions prevalent near the sea-ice margin of the Chukchi Sea. Prepare for and carry out field measurements in MIZPAC 80 cruise data from the Bering Sea.

Summary: Oceanographic measurements have been carried out during midsummer in the vicinity of the marginal sea-ice zone (MIZ) of the Chukchi Sea by the investigators since 1971. These studies are in support of submarine operations under ice. A scientific paper has been completed based on all the MIZPAC cruise data which describes the circulation in the vicinity of the ice margin and categorizes the various types of fronts found there. The ice melt-back pattern is shown to be closely associated with bathymetrically steered currents.

From February through March we conducted an oceanographic cruise to the ice-covered Bering Sea, the first cruise obtaining extensive data with a modern conductivity-temperature-depth recorder. Objectives were to study brine convection and accelerated brine production in areas of ice divergence and near shore and any consequent stratification; to obtain indications of circulation by tracing reverine dilution and searching for a cold, saline brine presumed to flow from the Gulf of Anadyr; to search for areas of fronts and temperature finestructure and to examine the oceanographic conditions at the ice edge, particularly the dynamic balance between ice export and melting. Reduction and analyses of these data are partially complete.

Publications: R. G. Paquette, and R. H. Bourke, "Circulation and Fronts Within the Marginal Sea-Ice Zone," submitted to Journal of Geophysical Research.



PROFESSOR R. G. PAQUETTE ABOARD  
A COAST GUARD ICEBREAKER IN THE  
MARGINAL ICE ZONE OF THE ARTIC

**Title:** Acoustic Variability Experiment

**Investigators:** E. B. Thornton, Associate Professor of Oceanography and T. P. Stanton, Adjunct Professor of Oceanography

**Sponsor:** NPS Foundation Research Program

**Objective:** Investigation of the phase and amplitude modulation of sound propagating through the upper layers of the ocean.

**Summary:** A successful experiment was conducted 2-26 August 1979. Acoustic amplitude and phase fluctuations were measured across a 400 meter path. The sound source and hydrophones were mounted on the shelf adjacent to the Carmel canyon at a depth of 35 meters. The depth of the canyon at this location is approximately 180 meters. The experiment was designed to measure only the direct path of sound and not receive either the surface or bottom reflected sound. The acoustic source signal was a composite pulse consisting of a 0.5 millisecond 20 kHz pulse followed by 5 milliseconds of pseudo-random noise. The pseudo-random noise has acoustic energy in the band from 4 to 20 kHz.

The ocean temperature structure was measured both at the source and the receivers using horizontal and vertical thermistor arrays in order to determine the structure and correlation functions for the temperature microstructure. A two current meter array measured the current shear; thermistors are also mounted on the current meter packages to give long time series of the temperature.

Computer software has been developed to process the packed acoustic digital data and the Pulse Code Modulated environmental data. A paper is being prepared describing these results.

**Publications:** E. B. Thornton and T. P. Stanton, "Temperature Induced Phase and Amplitude Fluctuations of 20 kHz Pulses in the Upper Ocean," in preparation.

Theses  
Directed: M. Wakeman, "Acoustic Amplitude Fluctuations  
of 20 kHz Pulses in the Upper Ocean," in  
preparation.

C. Christensen, "Temperature Microstructure  
Profiles in Monterey Bay," Master's Thesis,  
December 1979.

Title: Field Measurements of Surf Zone Energetics

Investigator: Edward B. Thornton, Associate Professor of Oceanography

Sponsor: Naval Oceanographic Atmospheric Administration.

Objective: The forcing function for sediment transport processes as a function of incident wave and beach parameters are measured in the field and characterized. Specific measurements include waves, onshore and alongshore velocities both inside and outside the surf zone and the winds and tides.

Summary: The forcing functions for sediment transport, the bed shear stress, turbulent or wave-induced velocities and mean currents, were measured during one-month experiments at Torrey Pines Beach, California, and Santa Barbara, California. The dynamics instrumentation included 22 electromagnetic current meters, 10 wave staffs, 9 pressure meters, 3 run-up meters and a wind anemometer. Intercomparisons of local pressure, velocity and sea surface elevation spectra for the wind wave-frequencies (0.05 - 0.3 Hz) were made using linear wave theory. Errors in both total variance and energy density in a particular frequency band are less than 20% both inside and outside the surf zone. Energy flux balance was calculated using measured quantities. Dissipation is due primarily to bottom friction. Measured bed shear stress coefficients ranged between .04 - .12.

Publications: R. T. Guza, and E. B. Thornton, "Local and Shoaled Comparisons of Sea Surface Elevations, Pressures and Velocities," Journal Geophys. Res., Vol. 85, 1524-1530, 1980.

R. T. Guza, and E. B. Thornton, "Wave Set-Up on a Natural Beach," accepted by Journal Geophys. Res., 1980.

D. A. Huntley, R. T. Guza, and E. B. Thornton, "Field Observations of Surf Beat: Part 1, Progressive Edge Waves," submitted to Journal of Geophys. Res., 1980.

E. B. Thornton, and R. T. Guza, "Longshore Currents and Bed Shear Stress," Proc. of Euromech '80, abstract, 1980.

Title: Kinematics of Breaking Waves in the Surf Zone

Investigator: Edward B. Thornton, Associate Professor of Oceanography

Sponsor: Office of Naval Research

Objective: Basic studies are being made on the kinematics of breaking waves within the surf zone in the field. The specific objectives of the proposed research are: (1) determine breaking criterion as a function of depth, beach slope and wave frequency and (2) determine the transformation of waves across the surf zone due to energy conversion and dissipation in the breaking process.

Summary: This research is being accomplished at various field sites for the conditions of spilling, plunging and collapsing breaking waves. Waves and orthogonal water particle velocities are measured at a large number of locations within the surf zone. The spectral characteristics and probability density functions for breaking waves and water particle velocities are calculated.

Measurements have been made on both sandy beaches and coral reefs. The dynamics of wave transformation are similar and are shown to be highly nonlinear. Energy is transferred from the primary spectral wave frequency to higher and lower frequencies in the shoaling and subsequent breaking process. The energy transferred to higher frequencies results in secondary waves at harmonic frequencies and a cascade of energy in a saturation range above the harmonic region. Stochastic wave transformation models of breaking waves are being developed and give reasonable comparisons with measurements.

Publications: R. T. Guza, and E. B. Thornton, "Local and Shoaled Comparisons of Sea Surface Elevations, Pressures and Velocities," Journal Geophys. Res., Vol. 85, 1524-1530, 1980.

R. T. Guza, and E. B. Thornton, "Wave Set-Up on a Natural Beach," accepted by Journal Geophys. Res., 1980.

D. A. Huntley, R. T. Guza, and E. B. Thornton, "Field Observations of Surf Beat: Part 1, Progressive Edge Waves," submitted to Journal of Geophys. Res., 1980.

E. B. Thornton and R. T. Guza, "Longshore Currents and Bed Shear Stress," Proc. of Euromech '80, abstract, 1980.

Title: Satellite and Synoptic Studies of Bio-Chemical Fronts in the Ocean

Investigator: Eugene D. Traganza, Associate Professor of Oceanography

Sponsor: Office of Naval Research

Objective: Development of a satellite referenced, synoptic model of the evolution and ecological significance of chemical fronts associated with upwelling and upper ocean mixing processes.

Summary: Satellite remote sensing of thermal patterns of the sea surface and underway sampling has led to the discovery of distinctively structured upwelling systems off Pt. Sur, CA. Thermal patterns with the appearance of cyclonic motion and sharp thermal fronts frequently form over Sur Canyon. At times upwelling waters also form giant plumes extending more than 250 km across the California current. In ten seasonal cruises since December 1978, nutrient fronts were strongly correlated with thermal fronts. However, upwelling fronts which are well defined by IR satellite imagery may not be nutrient rich. When they are, the strong chemical gradient is an excellent potential source of nutrients and may represent a nutrient flux to which production is quantitatively related. Microplankton in the surface layer (2.5m) show a preference to grow in the gradients and particularly on the equatorward edge of cyclonic upwelling systems. High adenosine triphosphate or "ATP-biomass" and high guanosine triphosphate or "GTP-productivity" were found in the strong thermochemical gradient associated with a newly upwelled system in June 1980. Although the surface circulation is not sufficiently known for computation of surface fluxes, a good correlation between productivity and nutrient flux is suggested qualitatively in the data. Images from satellite "color slicing" data have been calibrated to produce nutrient maps from which quantitative inference on mean nutrient fluxes and biomass distributions can be made.

**Publications:** E. D. Traganza, J. C. Conrad and L. C. Breaker, "Satellite Observations of a Cyclonic Upwelling System and Giant Plume in the California Current," in Coastal Upwelling Research, 1980. (1981) American Geophysical Union (In Press).

E. D. Traganza, D. A. Nestor and A. K. McDonald, "Satellite Observations of a Nutrient Upwelling Off the Coast of California," Journal of Geophysical Research, 85, 4101-4106 (1980).

E. D. Traganza, J. W. Swinnerton and C. H. Cheek, "Methane Supersaturation and ATP-Zooplankton Blooms in Near-Surface Waters of the Western Mediterranean and the Sub-tropical North Atlantic Ocean," Deep Sea Research, 26, 1237-1245 (1979).

**Presentations:** E. D. Traganza, "Chemical Fronts in the California Current," Gordon Research Conference on Chemical Oceanography, January 28 to February 1, 1980. Miramar Hotel, Santa Barbara, CA. (1980) (Poster Paper).

E. D. Traganza and J. C. Conrad, "Satellite and in situ Observations of Nutrient Upwelling and Microplanktonic Biomass in the California Current System," IDOE International Symposium on Coastal Upwelling, February 4-8, 1980. USC Conference Center, Los Angeles, California. (1980) AGU, AMS, ASLO, NSF. (Plenary Paper).

E. D. Traganza, "Satellite and in situ Studies of Upwelling Frontal Systems in the California Current," National Research Council Seminar-Workshop on Underway-Water Sampling Technology, February 11-12, 1980. National Academy of Sciences, Washington, D. C. (1980) (Panel Presentation).

**Thesis  
Directed:** W. E. Hanson, "Nutrient Study of Mesoscale Thermal Features Off Point Sur, California," Master's Thesis, September 1980.

S. H. Bronsink, "Microplankton ATP-Biomass and GTP-Productivity Associated with Upwelling Off Point Sur, California," Master's Thesis, September 1980.

J. E. Johnson, "Subsurface Dynamical Properties of Variable Features Seen in Satellite IR Imagery Off Point Sur and Their Acoustic Significance," Master's Thesis, June 1980.

R. W. Phoebus, "Distribution of Chlorophyll Biomass in Chemical Mesoscale Features Detected by IR Satellite Imagery," Master's Thesis, 1980.

J. W. Conrad, "Relationships Between Sea Surface Temperature and Nutrients in Satellite Detected Oceanic Fronts," Master's Thesis, March 1980.

Title: The Three-Dimensional Structure and Behavior of Mesoscale Ocean Features Associated With Their Remotely Sensed Surface Signatures

Investigators: J. B. Wickham, and S. P. Tucker, Associate Professor's of Oceanography

Sponsor: National Aeronautics and Space Administration

Objective: The main purpose of this research is to associate subsurface flow properties and thermal structure sensed by current meters and thermistors in array on the continental slope with surface temperature features inferred from satellite mounted infra red sensors. The in situ state is also sensed by hydrography.

Summary: Preliminary results from one thirty-day episode during a three-month interval of monitoring:  
  
Alongshore displacements of distinctive surface temperature features are consistent with metered near surface currents on the slope; and on-and-offshore displacements of surface warm features are associated with a conformal warming (down-welling) and cooling (upwelling) at mid-depths over the shelf. Both variations are for a time scale of a few days to a few tens of days.  
  
The up (down) welling changes are also verified by hydrographic surveying for the time scale of tens of days.  
  
The field work of this study has been completed. It includes some 25 hydrographic cruises and 13 current meter deployments which yielded 36 meter records covering about 2 months each. In FY 80 there were 4 meter deployments and 10 hydrographic cruises.

The satellite imagery is a useful tool for inferring some aspects of the subsurface circulation and structure in the near-shore (slope) region. Poor visibility due to clouds limits the applicability of this tool. There are also large oscillations at depth in both temperature and current which appear to have no surface image.

## DEPARTMENT OF MECHANICAL ENGINEERING

The research program in the Department of Mechanical Engineering has continued to expand. Projects are categorized as follows: applied mechanics; design and optimization; heat transfer; hydrodynamics and fluid mechanics; and materials science.

### APPLIED MECHANICS

Professor Cantin continued his work on interactive graphics. The GIFTS-5 system (a large interactive Finite Element System with a rich collection of graphics interactions) has been successfully installed in the PDP 11 system of the computer lab. This system has been used extensively in class work with the TEKTRONIX system 4081. His work with mini-computers adopted to solve large problems continues.

Professor R. E. Newton has continued to study applications of the finite element method to underwater shock problems. Efforts have been concentrated on the effects of cavitation and the resulting nonlinear mathematical models. Extensive results have been obtained for the response of a submarine-type structure to an incident shock wave. Effects of cavitation on peak stresses and equipment accelerations have been evaluated.

Professor Nunn has continued his investigation of the ball-obturated spinning tubular projectile. The objective of this effort is to develop a comprehensive computer-based model for the prediction of the internal and external ballistic performance of ball-obturated spinning tubular projectiles. An analytical model has been formulated to predict the motion of the ball within the spinning projectile. The analysis has been tested by a series of experiments and has been found to be essentially correct. Current efforts, analytical and experimental, are aimed at obtaining a better understanding of the aerodynamic loads that act upon the projectile during flight.

Professor D. Salinas has been active in the analytical investigation of a laminate composite plate subjected to severe thermal environment. The study utilizes computer programs for the thermo-mechanical response of the system.

Professor O. C. Zienkiewicz FRS, of the University of Wales, Swansea, the 1979-80 occupant of the NAVSEA Research

Chair, was author or co-author of 25 papers during his stay here. These were primarily devoted to applications of the finite element method to problems of heat conduction, fluid flow, and soil mechanics. Also included were a number of papers concerning algorithms for time integration in finite element applications to transient problems.

#### DESIGN AND OPTIMIZATION

Professor Vanderplaats initiated the development of a library of computer codes for automated design optimization. This research includes a survey of the state of the art in numerical optimization techniques as applied to engineering design, development and testing of a pilot computer code and eventual development, documentation and distribution of a general design optimization capability. Professor Vanderplaats also initiated research in machine component design using numerical optimization for the design of such components as torsion shafts made of composite materials and brakes.

Professor Nunn and his students have continued a program of research into the application of modern optimization methods to the design of vapor power systems. Two basic systems are under investigation: (1) marine power condensers and, (2) vapor power cycles typical of the Ocean Thermal Energy Conversion (OTEC) system.

Professors Kelleher and Vanderplaats have begun investigating the optimal design of liquid to gas heat exchangers in which variations in the overall heat transfer coefficient and the mean temperature difference are taken into account. They have also been investigating the optimal design of nonimaging solar collectors.

#### HEAT TRANSFER

Heat transfer considerations in the design of engineering systems have taken on new importance with the need to design for energy efficiency. The department has continued to engage in a vigorous heat transfer research program.

Professor P. J. Marto has continued his investigation into improving the performance of main steam condensers. In conjunction with Professor R. H. Nunn, efforts have been made to modify an existing one-dimensional condenser analysis computer code to incorporate the effects of vapor velocity and condensate inundation. This code has been compared

to experimental test data from a Navy condenser and will be used in the future to compare to test data gathered using a bundle of tubes to simulate an actual condenser under controlled test conditions. Professor Nunn is continuing his efforts to couple this code to a numerical optimization code. As part of this research program, a workshop on "Modern Developments in Marine Condensers" was held at NPS in March 1980. Approximately 50 experts from around the world participated, and the Proceedings of this meeting were published for wide distribution.

Professor Marto has also continued his investigation of the heat transfer performance of rotating wickless heat pipes. Recent work with Professor Salinas has concentrated on examining the performance of internally finned condenser sections using a finite element formulation. This analytical model has been coupled with an optimization code developed by Professor Vanderplaats to study which fin configuration will lead to the best heat pipe performance.

Professor Kelleher is continuing to investigate the heat transfer and fluid mechanics of turbomachinery blades. At the present time, the use of liquid crystal thermography for NACA series 65 blades is being explored in the M.E. Department's laminar flow wind tunnel. The technique will then be used to study the flow and heat transfer on blading in the rectilinear cascade.

Professor Kelleher has continued his investigation of heat transfer in curved ducts. Experiments to determine streamwise heat transfer variation on the concave wall are being initiated.

Professor Salinas and LT Vatikiotis are investigating the problem of a composite plate with air flow over one surface and subject to internal combustion. This activity is being performed for the Naval Weapons Center in China Lake. In addition, Professor Salinas is working on two-phase heat transfer and diffusion problems.

#### **HYDRODYNAMICS AND FLUID MECHANICS**

The study of the motion of compressible and incompressible fluids is vital to the development of advanced technology for the Navy. A strong research program has been developed in support of Navy needs.

Professor Sarpkaya has been in charge of a number of basic and applied research programs. He continued his investigation into the basic understanding of the vortex breakdown phenomenon over delta wings with the sponsorship of the Naval Air Systems Command. He continued to work on the strumming of smooth and rough cables and on hydroelastic oscillations with the cooperation of the Naval Construction Battalion Center. Professor Sarpkaya also continued his work on time-dependent flows about bluff bodies. An extensive numerical and experimental study has been carried out on the determination of wave and current induced forces on cylinders. The results of this investigation have received international attention and were incorporated into the design codes of offshore structures. Related studies on the determination of wave forces on risers, submarine pipelines, hydroelastic oscillations in oscillating flows are currently in progress.

Professor Sarpkaya and his students continued to explore both theoretically and experimentally the forces acting on missiles at high angles of attack. For this purpose, a special vertical water tunnel has been constructed and the impulsively started flow about cylinders have been simulated. Another time-dependent flow dealing with the Loss-of-Coolant-Accident in nuclear reactors has received considerable theoretical attention and resulted in the determination of the time history of the resulting fluid forces on bodies immersed in the suppression pool. Professor Sarpkaya has initiated two additional projects. One of these concerns the exploration and design of a low-speed velocity sensor for use in hovering helicopters under adverse environmental conditions. The second project deals with the motion of submerged bodies in fluids with density gradients. A special water channel is currently under construction for the study of this problem. The projects cited in the foregoing have been sponsored by the Naval Air Systems Command, Naval Construction Battalion Center, National Science Foundation, and the Defense Advanced Research Projects Agency.

Professor Pucci continued his theoretical and experimental investigation of the optimization of ship exhaust eductors. Experiments have been carried out with hot and cold gas with extremely encouraging results. The purpose of this investigation is to assist NAVSEA in the design of exhaust gas stack eductors for shipboard gas turbine propulsion plants. The program involves the design, construction, and testing of scale models, and the verification of analytical predictions.

Professor Pucci has initiated a comprehensive investigation of the effect of cannister geometry on carbon dioxide absorption by Sodasorb. The objective of the investigation is to determine the effect of certain cannister geometries on the effectiveness of absorption by carbon dioxide by its packed bed of Sodasorb. The effect of three different length-to-diameter ratios of cylindrical cannisters, the effect of bath temperature, the effect of flow rate, and the effect of initial carbon dioxide content has been accomplished. The project is sponsored by Naval Coastal Systems Laboratory.

#### MATERIALS SCIENCE

During FY80, two members of the Materials Science Group spent 6 months in England. Professor Jeff Perkins was on sabbatical leave for 6 months to do research at the University of Sussex. This work, which involved phase transformations in rapidly solidified alloys, is now continuing at NPS. Professor Perkins is also doing research for the Civil Engineering Laboratory, Port Hueneme, CA, in connection with problems of marine corrosion of steel reinforced concrete.

In March 1980, Professor Terry McNelley began a 12 months exchange with the Royal Military College of Science, Shrivenham. His place at NPS was taken by Dr. Michael Edwards of RMCS, who was able to continue much of Professor McNelley's ongoing research. This work is largely concerned with thermomechanical processing and substructural strengthening mechanics in high-magnesium-content Al-Mg alloys and in high-carbon steels such as 52100.

Professor Ken Challenger, who joined the faculty in 1979, has developed two main research areas. One of those concerns the interaction of creep, fatigue and environmental damage mechanisms, particularly as applied to low alloy steel for power generations system. His other area of activity is considering the fracture properties of weldments in HY-type hull steels.

Adjunct Research Professor D. Boone has continued his research on hot corrosion of gas turbine materials, where the particular focus is on the influence of surface coating and additive such as platinum on coating effectiveness.

Title: Installation of GIFTS 5 at NPS

Investigator: Gilles Cantin, Professor of Mechanical Engineering

Sponsor: None

Objective: Modify and install the GIFTS 5 system at NPS for use in subsequent research in Finite Element Methods.

Summary: The GIFTS 5 system is a very large interactive GRAPHICS package for Finite Element Analyses. It was decided to install the package on the PDP11 of the Computer Laboratory because of the uncertain status of the IBM 360 system. The system is now available and has received a limited amount of use even during the installation. It is expected that the system will be heavily used after proper self teaching guides are prepared.

Title: Installation of IGT80 in the IBM 360 for the  
4081 TEKTRONIX System

Investigator: Gilles Cantin, Professor of Mechanical Engineering

Sponsor: None

Objective: Install ASCII formatted communication system  
between the 4081 TEKTRONIX system to realize  
the full potential of intelligent, interactive  
alpha numeric and graphics communication  
with the IBM 360.

Summary: The peculiarities of the NPS IBM 360 system  
operating under CP/CMS time sharing made the  
installation particularly difficult and time  
consuming. Coupled with numerous other technical  
problems the difficulties took 8 months  
to be resolved. The system is now operational  
and a library of over 300 subroutines are  
available for distributed graphics operation  
of appropriate graphic terminals.

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A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH PROGRAM.(U)  
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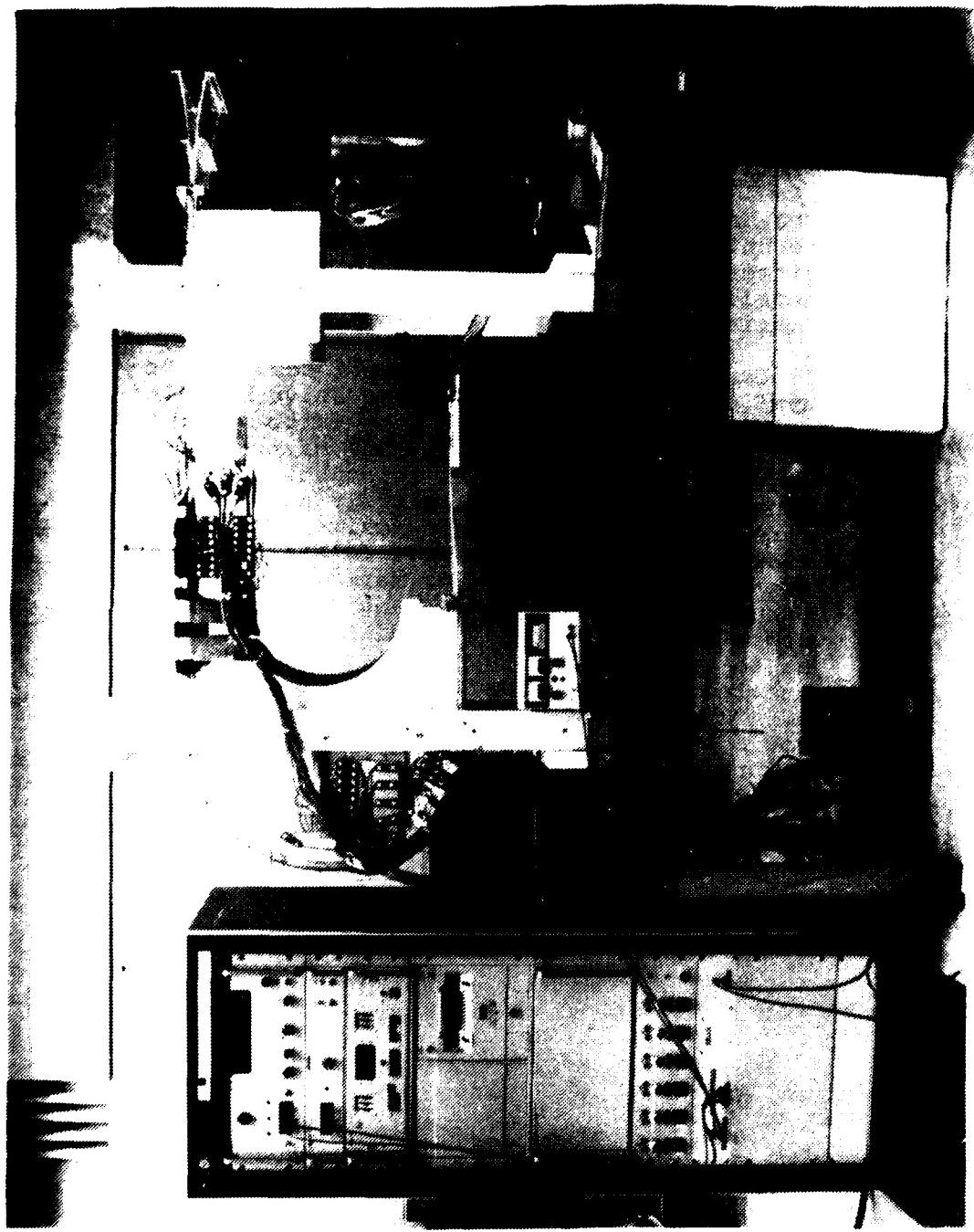
Title: Development of a Shore Facilities Fire Protection Program

Investigator: M. D. Kelleher, Associate Professor of Mechanical Engineering

Sponsor: Civil Engineering Laboratory

Objective: The objective of this project is to provide technical assistance to the Naval Civil Engineering Laboratory in the formulation and development of a Shore Facilities Fire Protection Program.

Summary: To carry out this study a great deal of the available literature has been surveyed. Personal contact by telephone or through personal visits has been made with many of the individuals and institutions throughout the country who are either actively engaged in fire research or are in a position to provide insight into what fire related problems are unique to the Navy or Marine Corps. The purpose in contacting as many individuals as practicable was to try to distill a concensus as to areas of the Navy's fire protection problem which are most critical and to identify those areas in which research efforts would be most likely to provide the highest return either in enhancing the ability to lower losses from unwanted fires or providing a better understanding of some of the important technical aspects of the fire problem.



EXPERIMENTAL APPARATUS FOR INVESTIGATION  
OF HEAT TRANSFER IN CURVED DUCTS.

Title: Exploratory Design and Development of Compact Naval Condensers

Investigators: P. J. Marto, Professor and Chairman of Mechanical Engineering, and R. H. Nunn, Associate Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: To develop a comprehensive computer-based model for the analysis of compact Naval condensers that can be optimized according to specified objective functions and constraints (cost, volume, weight, etc.).

Summary: An intensive survey of condenser design models, and the condensation heat transfer literature has been complete including input from foreign sources. The ORCON1 one-dimensional computer code has been operated to test its ability to correctly predict the effects of non-condensable gases, tube geometry, enhancement, etc., on condenser performance. An improved version has been developed which includes vapor velocity effects. The need to develop a two-dimensional code has been identified and efforts have been made to begin development of this code. Experimental test condenser with interchangeable tubes, bundle geometries, air concentration, etc., has been considered and tentative specifications have been determined. Heat transfer data have been gathered for a variety of tube shapes and diameters, including data for dropwise condensation.

Publications: C. Johnson, G. Vanderplaats, and P. J. Marto, "Marine Condenser Design Using Numerical Optimization," Journal of Mechanical Design, Vol. 102, pp. 469-475, July 1980.

P. J. Marto, "Heat Pipes for Cooling Electronic Equipment," ASME Winter Annual Meeting, New York, December 1979.

Theses Directed: K. P. Perkins, "An Experimental Study of Dropwise Condensation on Vertical Discs," Master's Thesis, December 1979.

H. Ciftci, "An Experimental Study of Film-wise Condensation on Horizontal Enhanced Condenser Tubing," Master's Thesis, December 1979.

V. J. Lynch, "A Comparative Study of a Stream Surface Condenser Computer Model to Field Test Data," Master's Thesis, December 1979.

D. E. Eshleman, "An Experimental Investigation of the Effects of Condensate Inundation on Heat Transfer in a Horizontal Tube Bundle," Master's Thesis, March 1980.

**Title:** FEM Analysis of an Internally Finned Rotating Heat Pipe

**Investigators:** P. J. Marto, Chairman and Professor of Mechanical Engineering, and G. Vanderplaats and D. Salinas Associate Professor's of Mechanical Engineering.

**Sponsor:** None

**Objective:** Development of an Analytical Model for the design of internally finned rotating heat pipes.

**Summary:** A mathematical model of a finned rotating heat pipe was formulated and developed into a finite element program. The formulation coupling the condensation and conduction problems (the conjugate problem) results in a nonlinear system.

**Publication:** A paper is near completion.

**Thesis  
Directed:** W. Davis, "Optimization of an Internally Finned Rotating Heat Pipe," Master's Thesis, September 1980.

Title: Improving the Heat Transfer Performance of Rotating Heat Pipes

Investigator: P. J. Marto, Professor and Chairman of Mechanical Engineering

Sponsor: None

Objective: The purpose of this study is to improve the heat transfer capability of rotating heat pipes used to cool rotating machinery by enhancing the condenser heat transfer characteristics.

Summary: A rotating heat pipe assembly was tested at rotational speeds of 700, 1400, and 2800 RPM with distilled water, ethyl alcohol and Freon-113 as working fluids. Tests were made using a variety of copper condenser configurations during film condensation conditions. Measured heat transfer rates were plotted versus the temperature difference between the saturated vapor and the cooling water inlet. Several internally finned condensers improved performance by over 200 percent when compared to a smooth-walled cylinder. Performance of these configurations depend upon fin helix angle and fin height.

Thesis  
Directed: H. J. Weigel, "Heat Transfer Performance of a Rotating Heat Pipe Using Different Condensers and Working Fluids," Master's Thesis, December 1979.

Patent  
Application: Patent applied for June 5, 1980, Navy Case Number 64,918.

Title: Nucleate Pool Boiling from Enhanced Surfaces to Dielectric Fluids

Investigator: P. J. Marto, Professor and Chairman of Mechanical Engineering

Sponsor: None

Objective: To obtain the nucleate pool boiling characteristics of commercially available enhanced surfaces in dielectric fluids to cool electronic equipment.

Summary: This research project was initiated by building an experimental apparatus to test different surfaces and working fluids. Three commercially available surfaces have been tested in Freon-113 and Fluorinert FC-72. Heat transfer data were gathered for heat fluxes from 100 W/m<sup>2</sup> to 200 KW/m<sup>2</sup>. It was found that the heat transfer coefficient of these surfaces could be as large as 10 times that of a plain surface.

Publications: P. J. Marto and LT V. J. Lepere, "Pool Boiling Heat Transfer from Enhanced Surfaces to Dielectric Fluids," paper submitted to 20th National Heat Transfer Conference, Milwaukee, Wisconsin, July 1981.

Thesis  
Directed: V. J. Lepere, "Pool Boiling Heat Transfer from Enhanced Surfaces to Dielectric Fluids," Master's Thesis, December 1980.

Title: An Evaluation of the Through-Thickness Properties of HY-80 Plate

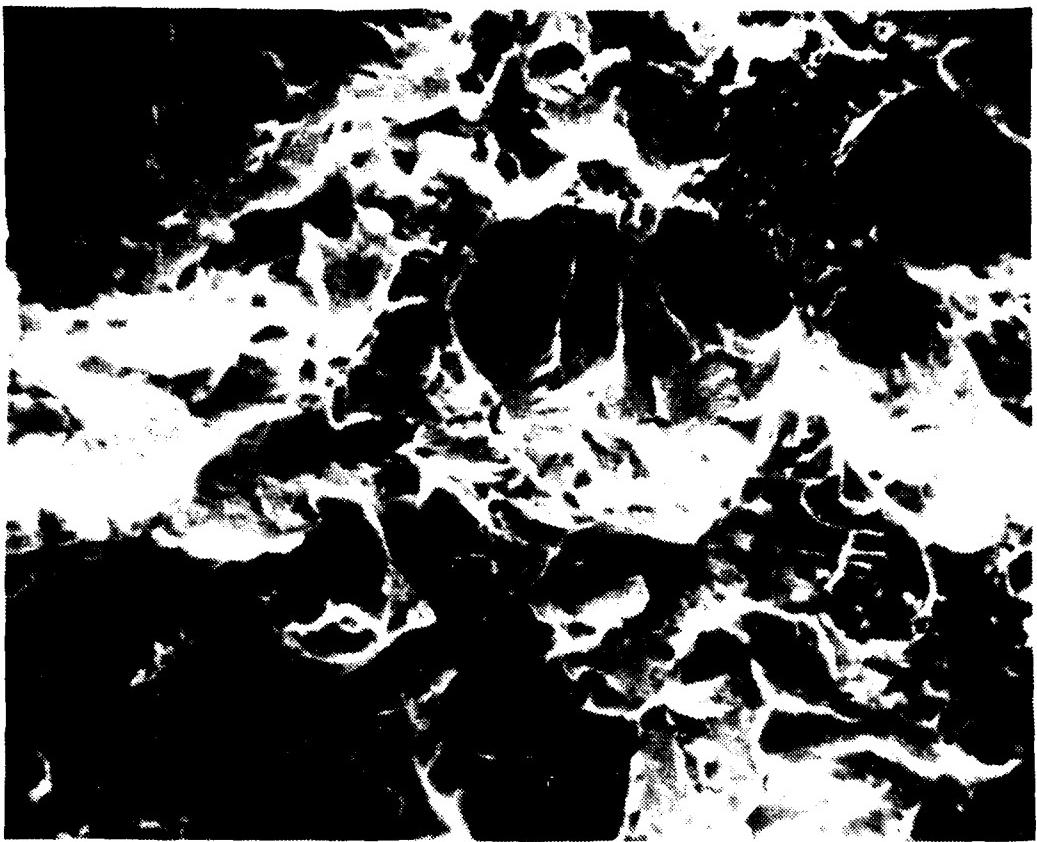
Investigators: T. R. McNelley, Associate Professor of Mechanical Engineering, and K. D. Challenger Assistant Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: Evaluate the merits of continuous casting versus conventional ingot casting for the production of HY-80 thick plate.

Summary: This research was directed toward solving an immediate problem incurred by the Navy when one supplier decided to produce HY-80 plate by the continuous casting process. During weld qualification of these plates an explosive bulge test was performed which failed. Research at NPS included a careful microstructural examination of both continuously cast plate and conventionally processed HY-80 which passed the explosive bulge test and a determination of the fracture resistance as a function of through-thickness location in each of the two plates. The microstructure at the plate mid-plane of the continuously cast plate was found to be coarser indicating insufficient deformation subsequent to casting. This coarse microstructure resulted in a significantly higher ductile to brittle transition temperature in this location of the plate. These results have contributed to the HY-80 specifications; The specification has been changed to require specific fracture properties at both the surface and center of the plate thereby assuring that the center of the plate receives sufficient deformation to eliminate the cast microstructure at the plate mid-plane.

Thesis  
Directed: R. Murphy, "A Comparison of the Through-Thickness Properties of the Strand-Cast and Ingot-Cast HY-80 Steel," Master's Thesis, in progress.



SCANNING ELECTRON MICROGRAPH (MAGNIFICATION 1500X) OF THE FRACTURE SURFACE OF A 2 INCH THICK EXPLOSION BULGE THAT IS USED IN THE QUALIFICATION OF CAST HY-130 STEEL. NOTE THAT THE FRACTURE MODE IS PREDOMINATELY CLEAVAGE WITH SOME MICROVOID COALESCENCE.

Title: Fracture Toughness Characterization of Thermomechanically Processed AISI 52100

Investigator: Terry R. McNelley, Associate Professor of Materials Science, Department of Mechanical Engineering

Objective: To investigate the influence of prior warm rolling on the response to heat treatment of the bearing steel AISI 52100 and to further characterize the influence of such processing on the fracture toughness and fatigue resistance of this steel.

Summary: Initial work on this steel concerned possible application of it to armor usage. However, such steels find general use in areas where high hardness is required, such as in bearings and tools. As such, this research has been directed increasingly to this area. The important results of this work to date are that prior warm rolling provides microstructural refinement, both of the ferrite matrix grain size and the carbides present. This microstructural refinement carries through subsequent heat treatment, generally, as heat treated hardness of steels experiencing prior warm rolling is increased. This is due, likely to grain refinement and increased rate of dissolution of the finer carbides. Fracture toughness testing of the heat treated materials has further revealed that increased fracture toughness also results from the grain refinement. However, a number of questions are raised. The influence of such grain refining process on the kinetics of carbide particle dissolution and, subsequently, on resultant residual carbide particle size, grain size, and retained austenite content have yet to be resolved. Future work will address these questions.

Conference  
Presentation: D. H. Boone, C. W. Schultz, T. R. McNelley  
and A Doig, "Effect of Initial Processing  
and Structure on the Hardening Response  
of AISI 52100 Bearings Steel," to be  
presented at the 110th Annual Meeting of  
AIME, Chicago, ILL, 23-27 February 1981.

Theses  
Directed: J. F. McCauley, "The Influence of Prior  
Warm Rolling on the Fracture Toughness of  
Heat Treated AISI 52100 Steel," Master's  
Thesis, March 1980.

I. Chung, "The Fatigue and Fractographic  
Characteristics of AISI 52100 Steel,"  
Master's Thesis, December 1979.

Title: Thermomechanical Processing of Aluminum-Magnesium Alloys Containing High Weight Percentages of Magnesium

Investigator: Terry R. McNelley, Associate Professor of Materials Science, Department of Mechanical Engineering

Sponsor: Naval Air Systems Command

Objective: Development of Thermomechanical Processing Procedures for Aluminum-Magnesium Alloys containing 8 to 14 weight percent Magnesium and characterization of the mechanical properties of the materials.

Summary: Several important results have been obtained in the past year. During warm rolling of such alloys, precipitation of the intermetallic precludes recrystallization, resulting in a fine dispersion of the intermetallic in an elongated grain structure which itself contains fine substructure stabilized by the precipitated intermetallic. Ternary alloying additions, e.g., Ca, Mn, etc., generally provide some additional solid solution strengthening. Further experiments have been conducted in this area of rolling procedure, and have resulted in the attainment of strengths up to 690 Mpa (1000KSI). Elevated temperature tension testing has revealed that strength drops rapidly above 100°C with an attendant large increase in elongation to fracture. Ductility at 300°C is in excess of 200%. Future work will examine the elevated temperature properties of these alloys and also investigate the ambient temperature fatigue response of these alloys. Preliminary fatigue test results suggest ductile failure modes at relatively high stresses.

Conference Presentation: T. R. McNelley, "High Strength Aluminum-Magnesium Alloys by Thermomechanical Processing," presented at the Symposium on New High Strength Aluminum Alloys for the Aerospace Industry, 109th Annual Meeting of AIME, Las Vegas, Nevada, 26 February 1980.

Theses  
Directed:

W. G. Speed, "An Investigation into the Influence of Thermomechanical Processing in Microstructure and Mechanical Properties of High Strength Aluminum-Magnesium Alloys," Master's Thesis, December 1979.

C. W. Chesterman, "Precipitation, Recovery and Recrystallization under Static and Dynamic Conditions for High Magnesium Aluminum-Magnesium Alloys," Master's Thesis, March 1980.

R. B. Johnson, "The Influence of Alloy Composition and Thermomechanical Processing Procedure on Microstructure and Mechanical Properties of High-Magnesium Aluminum-Magnesium Alloys," Master's Thesis, June 1980.

Patent  
Applications:

T. R. McNelley, "A Thermomechanical Treatment for Processing Eight to Twelve-Weight Percent Magnesium Aluminum-Magnesium Alloys to High Strength," Invention Disclosure filed with the Patent Counsel Office of Naval Research, San Francisco Area Office, Navy Case No. 65202, Serial PA358.

Title: Finite Element Analysis of Cavitation

Investigator: R. E. Newton, Professor of Mechanical Engineering

Sponsor: Defense Nuclear Agency

Objective: To include cavitation effects of fluid/structure interaction by modifying the conventional finite element model of the fluid field. This is a continuing program.

Summary: A finite element code using a displacement potential as dependent variable has been developed for studying shock induced cavitation in plane regions. This program has been used together with a structural program developed in a thesis project to determine circumstances under which cavitation occurs. The ultimate objective is to find out whether cavitation increases the severity of shock loading on submerged structures.

Publications:

- R. E. Newton, "Effects of Cavitation on Underwater Shock Loading - Plane Problem, Part 2," Defense Nuclear Agency Report, NPS69-80-001, April 1980.
- R. E. Newton, "Finite Element Study of Shock Induced Cavitation," ASCE Spring Conference, Portland, Oregon, April 1980.
- R. E. Newton, "Cavitation Simulation by Finite Element Methods," Presentation, Seminar, Structural Mechanics Division, Civil Engineering Department, University of California, Berkeley, 1980.

Title: Ball-Obturated Spinning Tubular Projectile

Investigator: Robert H. Nunn, Associate Professor of Mechanical Engineering

Sponsor: Naval Air Systems Command

Objective: This project has as its objective the development of a predictive capability by means of which the designer may create feasible designs that are best suited to ball-obturated projectile system specifications.

Summary: The motion of an unbalanced mass within a spinning cavity depends upon the torques applied to the mass by virtue of its motion relative to the cavity and the coupling of these torques with the inertial response characteristics of the spinning two-body system. This is the situation found when a bored sphere (ball obturator) is free to rotate within a spinning tubular projectile. The motion is gyrodynamic in nature, with the ball eventually orienting itself so that the hole in the ball is aligned with the projectile spin axis.

In order to formulate meaningful designs that are valid over a range of operating conditions it is necessary to understand this motion and to be aware of the influence of the various design parameters upon the performance of the ball-obturated projectile (BOP) system. Beyond the BOP system application, the problem attains further significance in relation to other mechanisms designed to exploit the inertial characteristics of the spinning unbalanced mass within a cavity: safe-arm devices, fuel controls, rotary speed governors, and a general class of high speed automatic hydromechanical switches.

The general equations governing the motion of the ball obturator have been formulated. The equations have been coded and solved for the cases of constant projectile spin rate and constant system (ball and projectile) kinetic energy. It has been demonstrated

that the ball motion is gyrodynamic in nature with the spinning of the ball within the projectile leading to retrograde precession and nutation.

Apparatus has been designed, built, and used to simulate the motion for cases in which the major applied force arises from the weight of the ball as it contacts the spinning cavity. Experiments conducted with the apparatus have verified the basic soundness of the analytical approach. Other items of progress include:

Background study and literature search.

Derivation of theoretical expressions for applied torques including aerodynamic as well as gravity effects.

Development of a linearized form for the implementation of approximate solutions and initial design guides.

Experimental evaluation of the effects of various design parameters under the influence of gravity alone.

The principal weakness in the analytical model lies in the uncertainties surrounding the description of the applied torques under flight conditions. These aerodynamic loads result from extremely complex fluid-mechanical interaction field and it is unlikely that a purely theoretical approach will yield satisfactory results. Consequently the major thrust of present efforts is towards the experimental and theoretical determination of the aerodynamic loads upon the ball/projectile system.

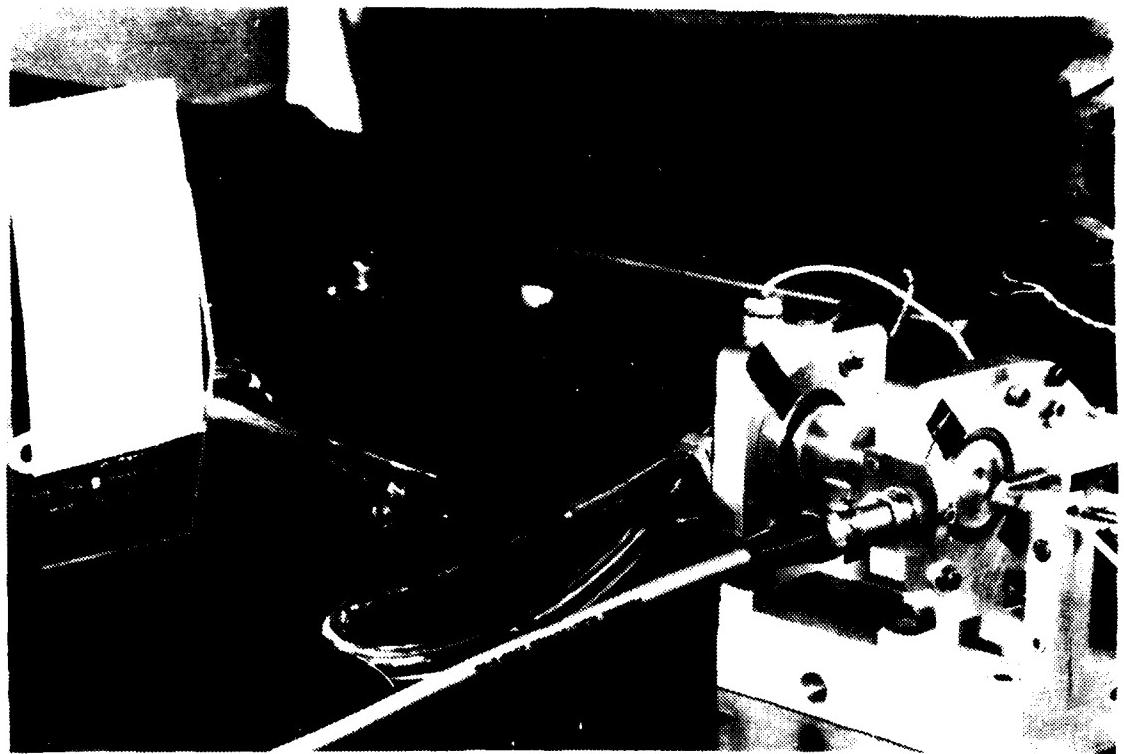
Publications: Quarterly progress reports to sponsor.

R. H. Nunn, "Motion of a Bored Sphere Within a Spinning Spherical Cavity," submitted to J. Dyn. Sys. Meas. and Control, ASME.

"Ball-Obturation of a Spinning Tubular Projectile," submitted J. Spacecraft and Rockets, AIAA.

Thesis  
Directed:

J. W. Bloomer, II, "Ball-Obturation of a Spin  
Stabilized Tubular Projectile," Master's Thesis,  
June 1980.



SIMULATION RIG AND LASER SENSING  
APPARATUS FOR INVESTIGATION OF THE  
BALL-OBTURATED SPINNING TUBULAR  
PROJECTILE.

Title: Effect of Cannister Geometry on Carbon Dioxide Absorption by Sodasorb

Investigator: Paul F. Pucci, Professor of Mechanical Engineering

Sponsor: Naval Coastal Systems Laboratory

Objective: To determine the effect of certain cannister geometries on the effectiveness of absorption of carbon dioxide by its packed bed of Soda-sorb.

Summary: The effect of three different length to diameter ratios of cylindrical cannisters, the effect of bath temperatures, the effect of flow rate, and the effect of initial carbon dioxide content has been accomplished. The current program concerns another cylindrical geometry family of lower L/D ratios than previously tested, as well as introducing annular rings and central disks.

Title: Gas Turbine Exhaust Gas Stack Eductor Systems

Investigator: Paul F. Pucci, Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: To determine the performance of scale models of gas turbine exhaust gas stack eductor systems and to recommend criteria for the design of gas turbine exhaust gas stack eductor systems for naval ships.

Summary: New and novel exhaust stack geometries were studied. One configuration was designed and fabricated and the initial tests in the cold flow facility were begun. Testing is continuing in FY 81.

Title: Advanced Composites Response Program

Investigator: David Salinas, Associate Professor of Mechanical Engineering

Sponsor: Naval Weapons Center

Objective: Development of an analytical model to predict the thermal and strength behavior of a composite structure in a fire environment.

Summary: An analytical model which included heat transfer by convection, conduction and radiation and mass transfer by diffusion and convection was given a finite element formulation. A computer program was completed and a number of analyses were undertaken. The results show the effects of wind, porosity, thickness, and how initial temperature and oxygen concentration distributions affect the behavior.

Publication: D. Salinas, "Heat Transfer in a Fibrous Composite with Combustion," submitted for publication in the ASME Journal of Heat Transfer.

Conference Presentation: D. Salinas, "Heat Transfer in a Fibrous Composite with Combustion," 1980 Natural Heat Transfer Conference in Ft. Lauderdale, FL., July 27-30, 1980.

Thesis Directed: C. S. Vatikiotis, "Analysis of Combustion and Heat Transfer in a Porous Graphite Medium," Engineer's Thesis, June 1980.

Title: Hydroelastic Oscillation of Cylinders in Harmonic Flow

Investigator: Turgut Sarpkaya, Distinguished Professor of Mechanical Engineering

Sponsor: National Science Foundation

Objective: Understanding of the fluid-mechanical phenomena leading to hydroelastic oscillations and the determination of the parameters controlling the oscillations.

Summary: The research program has continued on several fronts. Experiments have been performed with smooth and rough cylinders immersed in harmonically oscillating flow in a large U-shaped water tunnel. The results have been analyzed in terms of the governing parameters to determine the characteristics of synchronized oscillations. A numerical model based on the discrete vortex analysis has been developed and applied to steady and unsteady flows about cylinders. The model took into consideration the time-dependent boundary layer, redisccretization of shear layers, and circulation dissipation. The predictions of the model compared extremely well with those obtained experimentally.

Publications:

T. Sarpkaya, "Hydroelastic Response of Cylinders in Harmonic Flow," The Naval Architect, Journal of the Royal Institution of Naval Architects, Vol. 123, No. 3, May 1980, pp. 103-110.

T. Sarpkaya, and R. L. Shoaff, "Inviscid Model of Two Dimensional Vortex Shedding by a Circular Cylinder," American Institute of Aeronautics and Astronautics Journal, Vol. 17, No. 11, November 1979, pp. 1193-1200.

T. Sarpkaya, and R. L. Shoaff, "Numerical Modeling of Vortex-Induced Oscillations," Civil Engineering in the Oceans IV, Vol. I, September 1979, pp. 504-515, ASCE, New York.

Theses  
Directed:

M. Cinar, "Oscillating Flow About Tube  
bundles and Two-Cylinder Arrangements,"  
Master's and Engineer's Thesis, September  
1979.

S. Ozkaynak, "Hydroelastic Oscillations of  
Smooth and Rough Cylinders in Harmonic Flow,"  
Master's and Engineer's Thesis, September  
1979.

F. Rajabi, "Hydroelastic Oscillations of  
Smooth and Rough Cylinders in Harmonically  
Oscillating Flow," Ph.D Thesis, December  
1979.

D. Unsalan, "A Critical Assessment of  
Morison's Equation," Mechanical Engineer's  
Thesis, March 1980.

**Title:** Impulsively-Started Flow About Submarine-Shaped Bodies

**Investigator:** Turgut Sarpkaya, Distinguished Professor of Mechanical Engineering

**Sponsor:** David Taylor Naval Ship Research and Development Center

**Objective:** To perform experimental investigations in support of DTNSRDC's analytical modeling of separated flow past submarine-shaped bodies of special interest to naval hydrodynamics. Specifically, to experimentally determine the force coefficients acting on two-dimensional bodies in impulsively-started flows. Investigation will include, within the limitations of the experimental facility, force coefficients versus time for a variety of flow/body orientations (e.g., angle of attack) and Reynolds numbers. Experiments have been carried out in a vertical water tunnel with a D-shaped cylinder. Additional experiments will be performed during the coming year.

**Publication:** H. Kline, "Impulsive-Flow About Submarine-Shaped Bodies," Master's Thesis, (in preparation).

Title: Low Airspeed Sensors

Investigator: Turgut Sarpkaya, Distinguished Professor of Mechanical Engineering

Sponsor: Naval Air Systems Command

Objective: Air data measurement requirements for helicopters and V/STOL aircraft include omnidirectional low airspeed measurement, wind and gust data at remote and unprepared sites, rapid and accurate determination of the sink rate in vertical-mode operation, and the measurement of flow angle at low airspeed.

The characteristics of the existing low airspeed sensors have been critically assessed in terms of their accuracy, range, reliability, sensitivity to environmental conditions, electronics, and price. This led to the recommendation that new concepts and devices are needed to meet the air data needs of the current and future naval aircraft.

A speed sensor based on jet-interaction principle has been designed and is currently being tested.

Publication: T. Sarpkaya and R. E. Duncan, "Low Airspeed Sensors--A Technological Assessment," NPS Technical Report No. NPS-69SL80062-IR, June 1980.

Title: Development of a Library of Numerical Optimization Programs for Engineering Design

Investigator: Garret N. Vanderplaats, Associate Professor of Mechanical Engineering

Sponsor: None

Objective: To develop a library of FORTRAN programs for engineering design optimization using state-of-the-art techniques.

Summary: Initial steps have been taken to perform an extensive literature search to identify the most promising optimization algorithms. Work has begun on development of the FORTRAN program structure and twelve subroutines have been developed which will be incorporated into the program.  
This is anticipated to be a three year project and only the initial phases of the research have been performed at this time.

Thesis  
Directed: L. Madson, "Design Optimization Using the Augmented LaGrange Multiplier Technique," Master's Thesis, expected date of graduation March 1981.

Title: Optimum Design of Torsional Shafts Using Composite Materials

Investigator: Garret N. Vanderplaats, Associate Professor of Mechanical Engineering

Sponsor: NPS Foundation Research Program

Objective: To develop the analytic capability and FORTRAN program for the analysis of shafts made of multi-layered composite materials and couple this to a numerical optimization program to provide a general automated design capability.

Summary: The analytic capability has been developed to evaluate the response of hollow cylindrical shafts including synchronous whirl caused by mass imbalance. Failure modes which are evaluated include static and fatigue strength, maximum deflection, column buckling, axial and torsional cylinder buckling and critical speed. This has been programmed in FORTRAN and coupled to the optimization program COPES/CONMIN. The capability has been demonstrated with the design of steel shafts.

The constitutive equations have been formulated and programmed for shafts made of multilayered fiber composites and metal-composite combinations. Shafts have been designed for strength only and the remaining failure criteria (deflection, dynamic and buckling limits) are being incorporated into this general capability.

Research is continuing and is expected to result in a second Master's Thesis on the subject as well as a technical paper to be published in the open literature.

Thesis  
Directed: Virgilio S. Merced, "Drive Shaft Design Using Numerical Optimization," Master's Thesis, June 1980.

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